A Review on Biomedical Diagnostic Techniques

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Abstract: The biomedical/clinical engineering field that consists of and cover a vast array of different fields and devices examples of different areas of biomedical diagnostic techniques are radiographic and fluoroscopic x-ray, diagnostic ultrasound, LASER mammography, telemedicine film imaging processing, nuclear medicine, gamma cameras, medical imaging, computed tomography (CT), electron microscope, picture archiving and communication system, magnetic resonance imaging (MRI), physiological monitoring and optometry. Development of biomedical instrumentation technology to measure the physical and chemical information and signals emitted by the living body in a minimally or non-invasive and continuous manner, was responsible for establishment of the concept of patient monitoring within clinical medicine and thus contributed greatly to “enhancement of the quality of medical care.” Furthermore, social demands to “enhance and maintain a high quality of medical treatment, health and welfare” in this aging society are behind the anticipation for further developments in this field in the future. New diagnostic imaging includes plain film radiography, computed tomography, contrast enhanced radiography (ordinary radiography or plain film), digital subtraction angiography, nuclear imaging, magnetic resonance imaging (MRI) and diagnostic ultrasound. Plain film is the standard method of producing an image on an x-ray film by passing a beam of x-rays through being the examined area of the patient and used to enhance various body structures. In plain film examinations the natural contrast between the basic 4 radiographic densities are air, soft tissue (or water), fat, and bone is relied on to define abnormalities examples of plain film studies with which you are familiar with include chest, abdominal & skeletal radiographs.

Keywords: Biomedical/clinical engineering, biomedical diagnostic techniques, nuclear medicine, magnetic resonance imaging (MRI).

INTRODUCTION
The biomedical/clinical engineering field that consists of and cover a vast array of different fields and devices examples of different areas of biomedical diagnostic techniques are radiographic and fluoroscopic x-ray, diagnostic ultrasound, LASER mammography, telemedicine film imaging processing, nuclear medicine, gamma cameras, medical imaging, computed tomography (CT), electron microscope, picture archiving and communication system, magnetic resonance imaging (MRI), physiological monitoring and optometry. Development of biomedical instrumentation technology to measure the physical and chemical information and signals emitted by the living body in a minimally or non-invasive and continuous manner, was responsible for establishment of the concept of patient monitoring within clinical medicine and thus contributed greatly to “enhancement of the quality of medical care.” In the future, extremely delicate and precise microscopic surgery that cannot be performed by a surgeon can be possible through the combination of new surgery support systems and the surgeon’s skill. Thus, progresses in medical treatment technologies simultaneously promote the development of medicine itself. Furthermore, social demands to “enhance and maintain a high quality of medical treatment, health and welfare” in this aging society are behind the anticipation for further developments in this field in the future.
As analysis of the human genome is virtually complete, medical technology will now evolve into a technology where various interdisciplinary technologies are multiply combined, from the level of molecules and genes below 100 nm, to tissue and organs, and further to virtual human science per individual level. In addition to the technology of mass cell culture, the validation technology for assuring the quality of the cells and tissue produced is an essential element in allowing medical technology employing tissue engineering to mature into a clinical technology. Molecular imaging technology is of growing interest with relevance to the genetic treatment technology. Molecular imaging is of potential in enabling direct observation of function expression of genes in genetic treatments, while various molecular imaging techniques are also anticipated for other function-specific imaging. In clinical medicine, the structure and function of the protein produced by the gene is more often linked directly to the disease rather than the genetic information itself. The proteome is attracting post-genome attention, and it requires a method of analysis different from that of the genome. The protein chip is also being developed as a new technique. In 1986, the first recorded x-ray diagnostic use of x-ray. Before 1970, the diagnostic imaging study primarily relied on radiographs or x-ray films that were often supplemented by various contrast examinations for clinical problem solving. A revolution in diagnostic imaging began in the early 1970s with the development of computed tomography and soon rapid improvements in technology afforded us the ability to directly image areas of the body that previously were only accessible to surgeon’s knife. MRI joined the diagnostic armamentarium in the early 1980s and added a new modality for the diagnosis of disorders of whole body especially in the CNS and musculoskeletal system. New diagnostic imaging includes plain film radiography, computed tomography, contrast enhanced radiography (ordinary radiography or plain film), digital subtraction angiography, nuclear imaging, magnetic resonance imaging (MRI) and diagnostic ultrasound. Plain film is the standard method of producing an image on an x-ray film by passing a beam of x-rays through being the examined area of the patient and used to enhance various body structures. In plain film examinations the natural contrast between the basic 4 radiographic densities are air, soft tissue (or water), fat, and bone is relied on to define abnormalities examples of plain film studies with which you are familiar with include chest, abdominal & skeletal radiographs [1].

BIOMEDICAL DIAGNOSTIC TECHNIQUES
Many techniques were used for biomedical diagnosis. Some techniques are described below-

Magnetic Resonance Imaging [MRI]
Magnetic resonance imaging (MRI), nuclear magnetic resonance imaging (NMRI), or magnetic resonance tomography (MRT) is a medical imaging technique used in radiology to visualize detailed internal structures. It uses a powerful magnetic field to align the magnetization of some atoms in the body and uses radio frequency fields to systematically alter the alignment of this magnetization causes the nuclei to produce a rotating magnetic field detectable by the scanner - and this information is recorded to construct an image of the scanned area of the body. The magnetic resonance imaging machine is a harmless and non invasive diagnostic tool. It is used to detect abnormalities in the body and to produce images that can later lead to effective treatments. The MRI machine has become a widely used tool, helping in the diagnosis of anything from brain tumours to torn ligaments [2]. The first MRI image was published in 1973 and the first cross-sectional image of a living mouse was published in January 1974. The first studies performed on humans were published in 1977. All MRI machines are calibrated in tesla units. The strength of a magnetic field is measured in tesla or gauss Units. The stronger the magnetic field, the stronger the amount of radio signals which can be elicited from the body’s atoms and therefore the higher the quality of MRI images. MRI have three fields like low-field MRI= Under 0.2 Tesla (2,000 Gauss), mid-field MRI= 0.2 to 0.6 Tesla (2,000 Gauss to 6,000 Gauss) and high-field MRI= 1.0 to 1.5 Tesla (10,000 Gauss to 15,000 Gauss). In 1937, Isidor I. Rabi, observed the quantum phenomenon dubbed nuclear magnetic resonance (NMR). Raymond Damadian,
discovered that hydrogen signal in cancerous tissue is different from that of healthy tissue because tumors contain more water. When the MRI machine was switched off, the bath of radio waves from cancerous tissue will linger longer then those from the healthy tissue. In 1973, Paul Lauterbur, produced the first NMR image. Mike Goldsmith, one of the graduate students cobbled a wearable antenna coil to monitor the hydrogen broadcast detected by the coil. On July 3, 1977, nearly five hours after the start of the first MRI test, the first human scan was made as the first MRI prototype [3].

TYPES OF MRI SCANS
Magnetic resonance imaging or MRI is an imaging modality that utilizes radiofrequency and a strong magnetic field to obtain diagnostic images. The types of MRI scanners can often be differentiated by their magnetic field strength or tesla (T). Mainly 4 types of scanners were used for scanning like-

High-field MRI Scanners
In a clinical setting, high-field MRI scanners use a magnet of at least 1.5 T and up to 3.0 T. These are typically identified as closed MRI scanners. It is also known as tunnel or tube. A 1.5T MRI scanner is useful because it provides great image quality, fast scan times, and the ability to evaluate how certain structures in the body function. The 3.0T MRI scanner is great for visualizing very fine detail, such the vessels of the brain or heart [4].

Low-field MRI Scanners
Low-field MRI scanners or open MRI scanners have a range of 0.23 T-0.3 T. These scanners are useful for people who are claustrophobic or unable to have a closed MRI scan due to weight restrictions or body circumference [5].

Stand-up MRI Scanners
Stand-up MRI scanners are useful for those who are unable to lie down or who have conditions where the body part needs to be visualized while standing, bending or sitting. This type of scanner is best used for the spine and joints [6].

Extremity MRI Scanners
Extremity MRI scanners are limited-use scanners that specifically scan the extremities (elbows, hands, wrists, fingers, knees, ankles, feet and toes). These scanners provide an alternative to the full-body scanners [7].

PROCEDURE
When a person goes inside the powerful magnetic field of the scanner, the magnetic moments of some of these protons changes, and aligns with the direction of the field. In an MRI machine a radio frequency transmitter is briefly turned on, producing an electromagnetic field. The photons of this field have just the right energy (resonance frequency), to flip the spin of the aligned protons in the body. As the intensity and duration of application of the field increase, more aligned spins are affected. After the field is turned off, the protons decay to the original spin-down state and the difference in energy between the two states is released as a photon. It is these photons that produce the electromagnetic signal that the scanner detects. The frequency the protons resonate at depends on the strength of the magnetic field. As a result of conservation of energy, this also dictates the frequency of the released photons. The photons released when the field is removed have energy and therefore frequency due to the amount of energy the protons absorbed while the field was active. Additional magnetic fields are applied during the scan to make the magnetic field strength depend on the position within the patient, in turn making the frequency of the released photons dependent on position in a predictable manner. Position information can then be recovered from the resulting signal by the use of a Fourier transform. These fields are created by passing electric currents through specially-wound solenoids (gradient coils). Since these coils are within the bore of the scanner, there are large forces between them and the main field coils, producing most of the noise that is heard during operation. Without efforts to dampen this noise, it can approach 130 decibels (dB) with strong fields. An image can be constructed because the protons in different tissues return to their equilibrium state at different rates, which is a difference that can be detected.
Five different tissue variables - spin density, $T_1$ and $T_2$ relaxation times and flow and spectral shifts can be used to construct images. By changing the parameters on the scanner, this effect is used to create contrast between different types of body tissue or between other properties, as in diffusion MRI. Contrast agents may be injected intravenously to enhance the appearance of blood vessels, tumors or inflammation [8].

APPLICATIONS OF MRI

In clinical practice, MRI is used to distinguish pathologic tissue from normal tissue. One advantage of an MRI scan is that it is harmless to the patient. It uses strong magnetic fields and non-ionizing radiation in the radio frequency range, unlike CT scans and traditional x ray which both use ionizing.

Brain

Because of its superior sensitivity in delineating differences between various tissues, MRI is unsurpassed as an imaging modality for most disease processes in the central nervous system. The detection rate of most types of brain lesions by MRI exceeds 90%. MRI’s clinical advantage in early detection of disease is visually demonstrated as unmistakable contrast between gray and white matter and tumour ischemia/infarct, oedema, plaques, infection/abscess and haemorrhage.

Abdomen

MRI is an excellent screening study for the liver because of its great sensitivity in detecting lesions, especially metastases. It is very specific for cavernous haemangioma (the most common hepatic neoplasm) eliminating the need for liver biopsy with this diagnosis. MRI is also useful in detecting and monitoring the progress of other diseases such as hepatitis, hemochromatosis, and spread of intra-abdominal tumours, renal vein thrombosis, inferior vena cava, tumour invasion, venous flow pattern and portal vein obstruction. Applications include liver, tumours, cysts, haemorrhage abscess, extent or tumour into vascular structures, retroperitoneal lesions, aortic aneurysm, dissections, lymphadenopathy and trauma evaluation.

Pelvis/genitourinary

MRI offers greater tissue sensitivity, absence of bone artefact and ability to acquire multi planar views. Lack of ionizing radiation makes MRI a natural tool for the study of the reproductive organs and pelvic contents. In some instances, where ultrasound has demonstrated a pelvic mass of indeterminate signal, MRI has clarified its adnexal or uterine location. MRI aids in the staging of carcinoma of the endometrium, cervix, prostate and rectum. Applications includes primary and metastatic neoplasm and their extension, prostate cancer staging, rectal tumours, especially with pelvic extension, gynaecological disease, renal, peri renal tumours, cysts, abscesses, renal corticomedullary changes, renal vein invasion and thrombosis, bladder tumour – primary and metastatic.

Thorax

With the use of cardiac gating and fast scanning techniques, MRI studies of the chest have become the procedure of choice in many instances. Applications include benign tumors, primary and metastatic tumors, inflammatory, glaucomatous disease, extent of vascular involvement of lesion, cardiac/pericardial lesion, obstructed lung vs. tumour extension, elimination of partial volume errors on CT using multiplanar imagine.

Aortic Dissections, Aneurysms and Anomalies

Applications include cord tumours, myelomalacic disorders, syringomyelia, multiple sclerosis, congenital abnormalities, spinal stenosis, disc disease, trauma, osteomyelitis and discitis.

Musculoskeletal

The advantage of MRI over CT and other imaging modalities in evaluating pathological disorders of musculoskeletal tissue derives from the superior depiction of contrast between muscle, fat, vessels, tendons, ligaments, cartilage.

Disorders include bone and soft tissue neoplasm’s, different stages of infection and osteomyelitis, many types of soft tissue trauma, early bone a vascular necrosis and cartilage and ligament injuries, especially of the knee, shoulder hips and ankles.
Applications include osteonecrosis (aseptic/ischemic necrosis), osteomyelitis, soft tissues and bone neoplasms, primary and metastatic (eg. osteosarcoma, giant cell tumors), shoulder joint evaluation, arthritis, bone marrow pathology, wrist and elbow.

**Head & Neck**

With the application of improved surface coil techniques, MRI is emerging as the preferred imaging study for many of the extra cranial head and neck disease processes that in the past required CT. Applications include primary and metastatic tumors, infections, abscess, post-radiation evaluation [9, 10].

**BENEFITS OF MRI**

MRI is a non invasive imaging technique that does not involve exposure to ionizing radiation. MR images of the soft-tissue structures of the body—such as the heart, liver and many other organs—is more likely in some instances to identify and accurately characterize diseases than other imaging methods. This detail makes MRI an invaluable tool in early diagnosis and evaluation of many focal lesions and tumors. MRI has proven valuable in diagnosing a broad range of conditions, including cancer, heart and vascular disease, and muscular and bone abnormalities. MRI enables the discovery of abnormalities that might be obscured by bone with other imaging methods. MRI allows physicians to assess the biliary system noninvasively and without contrast injection. The contrast material used in MRI exams is less likely to produce an allergic reaction than the iodine-based contrast materials used for conventional x-rays and CT scanning. MRI provides a non invasive alternative to x-ray, angiography and CT for diagnosing problems of the heart and blood vessels.

**LIMITATIONS AND DISADVANTAGES OF MRI**

High-quality images are assured only if you are able to remain perfectly still or hold your breath, if requested to do so, while the images are being recorded. Difficult to lie still during imaging if you are anxious, confused or in severe pain. A person who is very large may not fit into the opening of a conventional MRI machine. The presence of an implant or other metallic object sometimes makes it difficult to obtain clear images and patient movement can have the same effect. Breathing may cause artifacts, or image distortions, during MRIs of the chest, abdomen and pelvis. Bowel motion is another source of motion artifacts in abdomen and pelvic MRI studies. This is less of a problem with state-of-the-art scanners and techniques. Although there is no reason to believe that magnetic resonance imaging harms the fetus, pregnant women usually are advised not to have an MRI exam unless medically necessary. MRI may not always distinguish between cancer tissue and edema fluid. MRI typically costs more and may take more time to perform than other imaging modalities. Till date, there has not been any disadvantage that has been documented. However, some cases may require caution. MRI technique can induce ECG changes (alteration in the electrical activity of the heart) in patients. However, this is only short lived. None of the observed changes have been found to be clinically significant. Some patients also experience claustrophobia i.e. morbid fear of closed places. The MRI examination poses almost no risk to the average patient when appropriate safety guidelines are followed. If sedation is used there are risks of excessive sedation. The technologist or nurse monitors your vital signs to minimize this risk. Although the strong magnetic field is not harmful in itself, implanted medical devices that contain metal may malfunction or cause problems during an MRI exam. There is a very slight risk of an allergic reaction if contrast material is injected. Such reactions usually are mild and easily controlled by medication. If you experience allergic symptoms, a radiologist or other physician will be available for immediate assistance. Nephrogenic systemic fibrosis is currently a recognized, but rare, complication of MRI believed to be caused by the injection of high doses of MRI contrast material in patients with very poor kidney function [11].

**COMPUTED TOMOGRAPHY SCAN [CT SCAN]**

X-ray computed tomography (CT) is a medical imaging method employing tomography created
by computer processing. Digital geometry processing is used to generate a 3-D image of the inside of an object from a large series of 2-D X-ray images taken around a single axis of rotation. CT produces a volume of data which can be manipulated, through a process known as windowing, in order to demonstrate various bodily structures based on their ability to block the X-ray beam. Although historically the images generated were in the axial or transverse plane, orthogonal to the long axis of the body, modern scanners allow this volume of data to be reformatted in various planes or even as volumetric (3D) representations of structures. In the early 1900s, Alessandro vallebona proposed a method to represent a single slice of the body on the radiographic film, known as tomography. Tomography had been one of the pillars of radiologic diagnostics until the late 1970s, when the availability of minicomputers and of the transverse axial scanning method – this last due to the work of Godfrey Hounsfield and South African-born Allaz McLeod Cormack – gradually supplanted it as the modality of CT. Mathematically, the method is based upon the use of the Radon Transform invented by Johann Radon in 1917. The first commercially viable CT scanner was invented by Sir Godfrey Hounsfield in Hayes, United Kingdom, at EMI central research laboratories using X-rays. The first EMI-Scanner was installed by Atkinson Morley hospital in Wimbledon, England, and the first patient brain-scan was done on 1 October 1971. The original 1971 prototype took 160 parallel readings through 180 angles, each 1° apart, with each scan taking a little over 5 minutes. The scanner had a single photomultiplier detector, and operated on the translate/rotate principle. The first production X-ray CT machine was limited to making topographic sections of the brain, but acquired the image data in about 4 minutes, and the computation time was about 7 minutes per picture. The water-tank was used to reduce the dynamic range of the radiation reaching the detectors. The images were relatively low resolution, being composed of a matrix of only 80 x 80 pixels. In the U.S., the first installation was at the Mayo Clinic. As a tribute to the impact of this system on medical imaging the Mayo Clinic has an EMI scanner on display in the radiology department. The first CT system that could make images of any part of the body and did not require the water tank was the ACTA (Automatic Computerized Transverse Axial) scanner designed by Robert S. Ledley, DDS, at Georgetown University. This machine had 30 photomultiplier tubes as detectors and completed a scan in only 9 translate/rotate cycles, much faster than the EMI-scanner. It used a DEC PDP11/34 minicomputer both to operate the servo-mechanisms and to acquire and process the images. The Pfizer drug company acquired the prototype from the university, along with rights to manufacture it. Pfizer then began making copies of the prototype, calling it the 200FS (FS meaning Fast Scan), which were selling as fast as they could make them. This unit produced images in a 256×256 matrix, with much better definition than the EMI-Scanner’s 80×80 [12].

**TYPES OF CT SCANS**

Computed tomography (CT) is a non-invasive procedure that uses x-rays to create images of organs or blood vessels inside the body. The CT scanner machine creates 2-D image slices of the body. A computer then combines the 2-D images to create highly detailed 3-D images. Doctors can then analyze the 3-D images of the organ or blood vessels of interest to diagnose tissue damage or vessel blockage. Different types of CT scans are used to examine different areas of the body.

**Chest CT**

A chest CT is used to analyze the size, shape, and location of the organs in the chest, especially the lungs. This type of CT scan is used to diagnose problems with the lungs such as lung tumors, blood clots, or problems with the pulmonary veins. For a chest CT, the x-rays from the CT scanner are focused on the chest area, and pictures from many different angles are taken. The University of California at San Diego (UCSD) Health System notes that a contrast dye may be administered through an IV to the patient prior to this, or any other type of CT scan. The contrast dye is visible on the images produced by the CT scanners and helps to highlight blood vessels.
Abdominal CT
This type of CT scan focuses the x-rays on the abdomen, and creates pictures of organs inside the abdomen. UCLA’s Endocrine Surgery website describes how a CT scan of the abdomen is used to diagnose many different types of disorders, such as intestinal damage or blockage, cysts, appendicitis, liver cirrhosis, an abdominal aortic aneurysm, or many different types of cancer.

Cardiac CT
A cardiac CT is used to take a detailed picture of the heart and/or the attached blood vessels. Contrast dye is often administered in conjunction with a cardiac CT to identify damage to the walls of the blood vessels or a blockage inside the blood vessels, according to the national heart lung and blood institute. A cardiac CT is also used to identify problems with the heart, such as valve defects.

Cranial CT
Cranial CT scan images are taken by focusing the x-rays on the head region. Medline Plus, an online medical encyclopedia sponsored by the U.S. National Library of Medicine, reports that a cranial CT is used to diagnose problems with the sinuses, brain, eye sockets, brain, or skull.

Full-body CT
In a full-body CT scan, x-rays are administered to the whole body, and detailed images of all organs, muscles, and blood vessels are created. The FDA reports that some medical imaging facilities are advertising full-body CT scans as a preventative measure to catch disorders of the body before they cause symptoms. According to the FDA, there is no known benefit in receiving full-body CT scans, and the radiation received during this procedure slightly increases a person’s risk of developing cancer later in life [13].

PROCEDURE OF CT-SCAN
A computed tomography (CT) scan uses X-rays to make detailed pictures of structures inside of the body. During the test, patient will lie on a table that is attached to the CT scanner, which is a large doughnut-shaped machine. The CT scanner sends X-rays through the body area being studied. Each rotation of the scanner takes less than a second and provides a picture of a thin slice of the organ or area. All of the pictures are saved as a group on a computer. They also can be printed. An iodine dye (contrast material) is often used to make structures and organs easier to see on the CT pictures. The dye may be used to check blood flow, find tumors, and look for other problems. The dye can be used in different ways. It may be put in a vein (IV) in your arm, or it may be placed into other parts of your body (such as the rectum or a joint) to see those areas better. For some types of CT scans you drink the dye. CT pictures may be taken before and after the dye is used. A CT scan can be used to study all parts of your body, such as the chest, belly, pelvis, arm, leg, liver, pancreas, intestines, kidneys, bladder, adrenal glands, lungs, and heart, blood vessels, bones and spinal cord. It uses a steady beam of X-rays to look at movement within the body. It allows the doctor to see your organs move or to guide a biopsy needle or other instrument into the right place inside your body. X-ray slice data is generated using an X-ray source that rotates around the object and X-ray sensors are positioned on the opposite side of the circle from the X-ray source. Cesium iodide was replaced during the 1980s by ion chambers containing high pressure Xenon gas. These systems were in turn replaced by scintillation systems based on photo diodes instead of photomultipliers and modern scintillation materials with more desirable characteristics. Newer machines (helical or spiral CT machines) with faster computer systems to generate three dimensional volumetric information (3D-CT scan) in turn viewable from multiple different perspectives on attached CT workstation monitors. This type of data acquisition requires enormous processing power, as the data are arriving in a continuous stream and must be processed in real-time. In conventional CT machines, an X-ray tube and detector are physically rotated behind a circular shroud (see the image above right); in the electron beam tomography (EBT) the tube is far larger and higher power to support the high temporal resolution. The electron beam is deflected in a hollow funnel-shaped vacuum chamber. X-rays are generated when the beam hits the stationary target. The detector is also stationary.
arrangement can result in very fast scans, but is extremely expensive. The most common technique in general use is filtered back projection, which is straight-forward to implement and can be computed rapidly. Mathematically, this method is based on the Radon transform. However, this is not the only technique available: the original EMI scanner solved the topographic reconstruction problem by linear algebra, but this approach was limited by its high computational complexity, especially given the computer technology available at the time. More recently, manufacturers have developed iterative physical model-based expectation maximization techniques. These techniques are advantageous because they use an internal model of the scanner's physical properties and of the physical laws of X-ray interactions. Pixels in an image obtained by CT scanning are displayed in terms of relative radio density. The pixel itself is displayed according to the mean attenuation of the tissue(s) that it corresponds to on a scale from +3071 (most attenuating) to -1024 (least attenuating) on the hounsfield scale. Pixel is a two dimensional unit based on the matrix size and the field of view. When the CT slice thickness is also factored in, the unit is known as a voxel, which is a three dimensional unit [14,15].

APPLICATIONS OF CT-SCAN

CT scans are used to study areas of the body and the arms or legs.

Chest (thorax)

A CT scan of the chest can look for problems with the lungs, heart, oesophagus, the major blood vessel (aorta), or the tissues in the centre of the chest. Some common chest problems a CT scan may find include infection, lung cancer, a pulmonary embolism, and an aneurism. It also can be used to see if cancer has spread into the chest from another area of the body.

Abdomen

A CT scan of the abdomen can find cysts, abscesses, infection, tumors, an aneurism, and enlarged lymph nodes, foreign objects, bleeding in belly, inflammatory bowel disease, and appendicitis.

Urinary Tract

A CT scan of the kidneys, ureters and bladder is called a CT KUB or CT urogram. This type of scan can find kidney stones, bladder stones, or blockage of the urinary tract. A special type of CT scan, called a CT intravenous pyelogram (IVP), uses injected dye (contrast material) to look for kidney stones, blockage, growths, infection, or other diseases of the urinary tract.

Liver

A CT scan can find liver tumors, bleeding from the liver and liver diseases. A CT scan of the liver can help determine the cause of jaundice.

Pancreas

A CT scan can find a tumour in the pancreas or inflammation of the pancreas (pancreatitis).

Gallbladder and Bile Ducts

To check for blockage of the bile ducts. Gallstones occasionally show up on a CT scan but other tests, such as ultrasound, usually are used to find problems with the gallbladder and bile ducts.

Adrenal Glands

A CT scan can find tumors or enlarged adrenal glands.

Spleen

A CT scan can be used to check for an injury to the spleen or the size of the spleen.

Pelvis

A CT scan can look for problems of organs in the pelvis. For a woman, these include the uterus, ovaries and fallopian tubes. For a man, the pelvic organs include the prostate gland and the seminal vesicles.

Arm or Leg

A CT scan can look for problems of the arms or legs, including the shoulder, elbow, wrist, hand, hip, knee, ankle or foot.

Head

CT scanning of the head is typically used to detect infarction, tumors, calcifications, of the above, hypo dense (dark) structures indicate infarction or tumors, hyper dense (bright)
structures indicate calcifications and hemorrhage and bone trauma can be seen as disjunction in bone windows.

**Chest**

CT can be used for detecting both acute and chronic changes in the lung parenchyma, that is, the internals of the lungs. It is particularly relevant here because normal two-dimensional x-rays do not show such defects. A variety of different techniques are used, depending on the suspected abnormality. For evaluation of chronic interstitial processes (emphysema, fibrosis, and so forth), thin sections with high spatial frequency reconstructions are used; often scans are performed both in inspiration and expiration. This special technique is called high resolution CT (HRCT). HRCT is normally done with thin sections with skipped areas between the thin sections. Therefore it produces a sampling of the lung and not continuous images. Continuous images are provided in a standard CT of the chest [16,17].

**LIMITATIONS OF CT SCAN**

**Exorbitantly Expensive**

These prices can create a significant financial burden for patients, especially those who undergo multiple CT examinations. And for those without medical insurance, the burden can be devastating. Yet, the medical literature and teachers in medical schools remain silent when it comes to the monetary specifics of CT. No wonder physicians know so little about the expense of this test.

**Delivers High Dose of Radiation**

Even the few who know how much CT costs almost invariably are ignorant of how much radiation it delivers. In a similar questionnaire administered in England to 130 doctors, including 10 consultant radiologists, 97% of the answers were underestimates of the actual doses of radiation that patients receive during various radiologic investigations. Several factors determine the radiation dose a patient receives from CT. These include the design of the scanner, size of the patient, anatomic volume scanned, scanning protocol, technique used, and quality of the x-ray beam. Typical effective radiation doses in adults range from about 2 mSv (0.2 rad) for head CTs to about 8 to 10 mSv for CTs of the chest, abdomen, or pelvis. These latter doses are high compared to those of natural background radiation, which is about 3mSv/year. Thus, it would take a person 3.3 years to get the same amount of background radiation that an abdominal CT delivers in less than a minute.

**Promotes Laziness**

Physicians order CTs for a variety of reasons. From my vantage point, the most common reason is “fishing”—scanning the body part thought to be the source of the patient’s complaint or problem, in the hope that a diagnosis will somehow be reeled in. In such cases, the physician takes a brief medical history, may or may not examine the patient, and, guided by the chief complaint, proceeds directly to CT scanning. This approach has many attractive features. It takes little of the physician’s time, requires no special expertise, demands no discriminate thought, and serves as an easy, convenient way to obtain a lot of information quickly. In fact, the physician need not even see the patient before ordering the test.

**Safety Concerns**

The increased use of CT scans has been the greatest in two fields: screening of adults (screening CT of the lung in smokers, virtual colonoscopy, CT cardiac screening and whole-body CT in asymptomatic patients) and CT imaging of children. Shortening of the scanning time to around 1 second, eliminating the strict need for subject to remain still or be sedated, is one of the main reasons for large increase in the pediatric population (especially for the diagnosis of appendicitis). CT scans of children have been estimated to produce non-negligible increases in the probability of lifetime cancer mortality, leading to calls for the use of reduced current settings for CT scans of children. These calculations are based on the assumption of a linear relationship between radiation dose and cancer risk; this claim is controversial, as some but not all evidence shows that smaller radiation doses are not harmful. Estimated lifetime cancer mortality risks attributable to the radiation
exposure from a CT in a 1-year-old are 0.18% (abdominal) and 0.07% (head)—an order of magnitude higher than for adults—although those figures still represent a small increase in cancer mortality over the background rate. The additional risk is still very low (0.35%) compared to the background risk of dying from cancer (23%). However, if these statistics are extrapolated to the current number of CT scans, the additional rise in cancer mortality could be 1.5 to 2%. Furthermore, certain conditions can require children to be exposed to multiple CT scans. Again, these calculations can be problematic because the assumptions underlying them could overestimate the risk. In 2009 a number of studies appeared that further defined the risk of cancer that may be caused by CT scans. One study indicated that radiation by CT scans is often higher and more variable than cited and each of the 19,500 CT scans that are daily performed in the US is equivalent to 30 to 442 chest x-rays in radiation. It has been estimated that CT radiation exposure will result in 29,000 new cancer cases just from the CT scans performed in 2007. The most common cancers caused by CT are thought to be lung cancer, colon cancer and leukemia with younger people and women more at risk. These conclusions, however, are criticized by the American College of Radiology (ACR) that maintains that the life expectancy of CT scanned patients is not that of the general population and that the model of calculating cancer is based on total body radiation exposure and thus faulty. CT scans can be performed with different settings for lower exposure in children, although these techniques are often not employed. Surveys have suggested that currently, many CT scans are performed unnecessarily. Ultrasound scanning or magnetic resonance imaging is alternatives (for example, in appendicitis or brain imaging) without the risk of radiation exposure. Although CT scans come with an additional risk of cancer (it can be estimated that the radiation exposure from a full body scan is the same as standing 2.4 km away from the WW II atomic bomb blasts in Japan), especially in children, the benefits that stem from their use outweighs the risk in many cases. Studies support informing parents of the risks of pediatric CT scanning [18].

ELECTROENCEPHALOGRAPHY [EEG]

Electroencephalography (EEG) is the recording of electrical activity along the scalp produced by the firing of neurons within the brain. EEG refers to the recording of the brain’s spontaneous electrical activity over a short period of time, usually 20–40 minutes, as recorded from multiple electrodes placed on the scalp. In neurology, the main diagnostic application of EEG is in the case of epilepsy, as epileptic activity can create clear abnormalities on a standard EEG study. A secondary clinical use of EEG is in the diagnosis of coma, encephalopathies, and brain death. EEG used to be a first-line method for the diagnosis of tumors, stroke and other focal brain disorders. Derivatives of the EEG technique include evoked potentials (EP), which involves averaging the EEG activity time-locked to the presentation of a stimulus of some sort (visual, somatosensory or auditory). A timeline of the history of EEG is given by Swartz Richard Caton (1842–1926), presented his findings about electrical phenomena of the exposed cerebral hemispheres of rabbits and monkeys. In 1890, Adolf Beck published an investigation of spontaneous electrical activity of the brain of rabbits and dogs that included rhythmic oscillations altered by light. In 1912, Vladimirovich Pravdich-Neminsky published the first animal EEG and the evoked potential of the mammalian (dog). In 1914, Napoleon Cybulski and Jelenska-Macieszyna photographed EEG-recordings of experimentally induced seizures. German physiologist and psychiatrist Hans Berger (1873–1941) recorded the first human EEG in 1924. In 1935 Gibbs, Davis and Lennox described interictal spike waves and the 3 cycles/s pattern of clinical absence seizures, which began the field of clinical electroencephalography. Subsequently, in 1936 Gibbs and Jasper reported the interictal spike as the focal signature of epilepsy. In 1936, the first EEG laboratory opened at Massachusetts General Hospital. In 1947, The American EEG Society was founded and the first International EEG congress was held. In 1950s, William Grey Walter developed an adjunct to EEG called EEG topography, which allowed for the mapping of electrical activity across the surface of the brain. This enjoyed a brief period of popularity in the 1980s and seemed especially
promising for psychiatry. It was never accepted by neurologists and remains primarily a research tool [19-21].

PROCEDURE OF EEG
In conventional scalp EEG, by placing electrodes on the scalp with a conductive gel or paste, usually after preparing the scalp area by light abrasion to reduce impedance due to dead skin cells and recording is obtained. A smaller number of electrodes are typically used when recording EEG from neonates. Additional electrodes can be added to the standard set-up when a clinical or research application demands increased spatial resolution for a particular area of the brain. High-density arrays can contain up to 256 electrodes more-or-less evenly spaced around the scalp. Each electrode is connected to one input of a differential amplifier; a common system reference electrode is connected to the other input of each differential amplifier. These amplifiers amplify the voltage between the active electrode and the reference (typically 1,000–100,000 times, or 60–100 dB of voltage gain). In analog EEG, the signal is then filtered, and the EEG signal is output as the deflection of pens as paper passes underneath. Most EEG systems these days, however, are digital, and the amplified signal is digitized via an analog-to-digital converter, after being passed through an anti-aliasing filter. Analog-to-digital sampling typically occurs at 256–512 Hz in clinical scalp EEG; sampling rates of up to 20 kHz are used in some research applications. During the recording, a series of activation procedures may be used. These procedures include hyperventilation, photic stimulation (with a strobe light), eye closure, mental activity, sleep and sleep deprivation. During (inpatient) epilepsy monitoring, a patient’s typical seizure medications may be withdrawn. The digital EEG signal is stored electronically and can be filtered for display. Typical settings for the high-pass filter and a low-pass filter are 0.5-1 Hz and 35–70 Hz, respectively. The high-pass filter typically filters out slow artifact, such as electro galvanic signals and movement artifact, whereas the low-pass filter filters out high-frequency artifacts, such as electromyographic signals. An additional notch filter is typically used to remove artifact caused by electrical power lines (60 Hz in the United States and 50 Hz in many other countries). As part of an evaluation for epilepsy surgery, it may be necessary to insert electrodes near the surface of the brain, under the surface of the duramater. Depth electrodes may also be placed into brain structures, such as the amygdala or hippocampus, structures, which are common epileptic foci and may not be seen clearly by scalp EEG [22-24].

APPLICATIONS
Routine EEG is typically used in the following clinical circumstances: distinguish epileptic seizures from other types of spells, such as psychogenic non-epileptic seizures, syncope (fainting), sub-cortical movement disorders and migraine variants, to differentiate “organic” encephalopathy or delirium from primary psychiatric syndromes such as catatonia, to serve as an adjunct test of brain death, to prognosticate, in certain instances, in patients with coma and to determine whether to wean anti-epileptic medications. At times, a routine EEG is not sufficient, particularly when it is necessary to record a patient while he/she is having a seizure. In this case, the patient may be admitted to the hospital for days or even weeks, while EEG is constantly being recorded (along with time-synchronized video and audio recording). A recording of an actual seizure (i.e., an ictal recording, rather than an inter-ictal recording of a possibly epileptic patient at some period between seizures) can give significantly better information about whether or not a spell is an epileptic seizure and the focus in the brain from which the seizure activity emanates. Epilepsy monitoring is typically done by to distinguish epileptic seizures from other types of spells, such as psychogenic non-epileptic seizure, syncope (fainting), sub-cortical movement disorders and migraine variants, to characterize seizures for the purposes of treatment and to localize the region of brain from which the seizure activity emanates. Epilepsy monitoring may be used to monitor the depth of anaesthesia, as an indirect indicator of cerebral perfusion in carotid endarterectomy and to monitor amobarbital effect during the wada test. EEG can also be used in intensive care units for brain function
monitoring by to monitor for non-convulsive seizures/non-convulsive status epilepticus, to monitor the effect of sedative/anaesthesia in patients in medically induced coma (for treatment of refractory seizures or increase intracranial pressure) and to monitor for secondary brain damage in conditions such as subarachnoid haemorrhage (currently a research method). Neuro feedback remains an important extension, and in its most advanced form is also attempted as the basis of brain computer interfaces. The EEG is also used quite extensively in the field of neuromarketing. There are many commercial products substantially based on the EEG. Honda is attempting to develop a system to move its Asimo robot using EEG, a technology it eventually hopes to incorporate into its automobiles. EEGs have been used as evidence in trials in the Indian state of Maharashtra.

LIMITATIONS OF EEG

EEG has several limitations. Most important is its poor spatial resolution. EEG is most sensitive to a particular set of post-synaptic potentials: those generated in superficial layers of the cortex, on the crests of gyri directly abutting the skull and radial to the skull. Dendrites, which are deeper in the cortex, inside sulci, in midline or deep structures (such as the cingulate gyrus or hippocampus), or producing currents that are tangential to the skull, have far less contribution to the EEG signal. The meninges, cerebrospinal fluid and skull “smear” the EEG signal, obscuring its intracranial source. It is mathematically impossible to reconstruct a unique intracranial current source for a given EEG signal as some currents produce potentials that cancel each other out. This is referred to as the inverse problem. However, much work has been done to produce remarkably good estimates of, at least, a localized electric dipole that represents the recorded currents [25].

ELECTROCARDIOGRAPHY [ECG OR EKG]

Electrocardiography is a trans thoracic interpretation of the electrical activity of the heart over time captured and externally recorded by skin electrodes. The ECG works mostly by detecting and amplifying the tiny electrical changes on the skin that are caused when the heart muscle depolarizes during each heart beat. At rest, each heart muscle cell has a charge across its outer wall, or cell membrane. Reducing this charge towards zero is called depolarization, which activates the mechanisms in the cell that cause it to contract. During each heartbeat a healthy heart will have an orderly progression of a wave of depolarization that is triggered by the cells in the senatorial node, spreads out through the atrium, passes through intrinsic conduction pathways and then spreads all over the ventricles. This is detected as tiny rises and falls in the voltage between two electrodes placed either side of the heart which is displayed as a wavy line either on a screen or on paper. This display indicates the overall rhythm of the heart and weaknesses in different parts of the heart muscle. Usually more than 2 electrodes are used and they can be combined into a number of pairs (For example: Left arm (LA), right arm (RA) and left leg (LL) electrodes form the pairs: LA+RA, LA+LL, RA+LL). The output from each pair is known as a lead. Each lead is said to look at the heart from a different angle. It is the best way to measure and diagnose abnormal rhythms of the heart, particularly abnormal rhythms caused by damage to the conductive tissue that carries electrical signals, or abnormal rhythms caused by electrolyte imbalances. In a myocardial infarction (MI), the ECG can identify if the heart muscle has been damaged in specific areas, though not all areas of the heart are covered. The ECG cannot reliably measure the pumping ability of the heart, for which ultrasound-based (echocardiography) or nuclear medicine tests are used. It is possible to be in cardiac arrest with a normal ECG signal (a condition known as pulse less electrical activity). Alexander Muirhead is reported to have attached wires to a feverish patient’s wrist to obtain a record of the patient’s heartbeat in 1872. This activity was directly recorded and visualized using a Lippmann capillary electrometer by John Burdon Sanderson. The first to systematically approach the heart from an electrical point-of-view was Augustus Waller. His electrocardiograph machine consisted of a Lippmann capillary electrometer fixed to a projector. The trace from the heartbeat was projected onto a photographic plate which was
itself fixed to a toy train. This allowed a heartbeat to be recorded in real time. Einthoven assigned the letters P, Q, R, S and T to the various deflections, and described the electrocardiographic features of a number of cardiovascular disorders [26-28].

**ECG GRAPH PAPER**

The output of an ECG recorder is a graph with time represented on the x-axis and voltage represented on the y-axis. A dedicated ECG machine would usually print onto graph paper which has a background pattern of 1mm squares (often in red or green), with bold divisions every 5mm in both vertical and horizontal directions. It is possible to change the output of most ECG devices but it is standard to represent each mV on the y axis as 1 cm and each second as 25mm on the x-axis (that is a paper speed of 25mm/s). Faster paper speeds can be used - for example to resolve finer detail in the ECG. At a paper speed of 25 mm/s, one small block of ECG paper translates into 40 ms. Five small blocks make up one large block, which translates into 200 ms. Hence, there are five large blocks per second. A calibration signal may be included with a record. A standard signal of 1 mV must move the stylus vertically 1 cm that is two large squares on ECG paper. The electrode placement along with their label is shown in table 1.

**PROCEDURE OF ECG**

Assess the patient and monitor the cardiac status. Administer oxygen per patient condition as tolerated if patient is unstable, definitive treatment is the priority. If the patient is stable or stabilized after treatment, perform a 12-lead ECG. Prepare ECG monitor and precordial lead cables. Enter patient demographic data. Expose the chest and prep as necessary. Modesty should be considered. Apply chest leads and limb leads as follows: RA (right arm), LA (left arm), RL (right leg), LL (left leg), V1 (4th intercostal space at right sternal border), V2 (4th intercostal space at left sternal border), V3 (directly between V2 and V4), V4 (5th intercostal space at midclavicular line), V5 (Level with V4 at the left anterior axillary line), V6 (Level with V5 at the left midaxillary line). Instruct patient to remain still. Press the 12 lead acquisition buttons on the monitor. If the monitor detects a problem, such as loose leads, bad connection, noisy data, the monitor will alarm. The EMT-P should address the problem. Once acquired, transmit to the appropriate receiving facility. Contact the receiving facility to notify them of the patient and the incoming 12-lead. Monitor and reassess the patient enroute and continue treatment protocol. Attach a copy of the 12-lead with the patient’s record at the hospital. Document the procedure, time, results and findings on the ACR [29].

**APPLICATIONS OF ECG**

Electrocardiogram (ECG)-gated myocardial perfusion single photon emission computed tomography (SPECT) can be used to assess myocardial perfusion and left ventricular function simultaneously. Various clinical applications of gated SPECT and their usefulness have been reported. The functional variables that can be

<table>
<thead>
<tr>
<th>Electrode label</th>
<th>Electrode placement</th>
</tr>
</thead>
<tbody>
<tr>
<td>RA</td>
<td>On the right arm, avoiding thick muscle.</td>
</tr>
<tr>
<td>LA</td>
<td>In the same location that RA was placed, but on the left arm this time.</td>
</tr>
<tr>
<td>RL</td>
<td>On the right leg, lateral calf muscle</td>
</tr>
<tr>
<td>LL</td>
<td>In the same location that RL was placed, but on the left leg this time.</td>
</tr>
<tr>
<td>V1</td>
<td>In the fourth intercostal space (between ribs 4 &amp; 5) just to the right of the sternum (breastbone).</td>
</tr>
<tr>
<td>V2</td>
<td>In the fourth intercostal space (between ribs 4 &amp; 5) just to the left of the sternum.</td>
</tr>
<tr>
<td>V3</td>
<td>Between leads V₂ and V₄.</td>
</tr>
<tr>
<td>V4</td>
<td>In the fifth intercostal space (between ribs 5 &amp; 6) in the mid-clavicular line (the imaginary line that extends down from the midpoint of the clavicle (collarbone)).</td>
</tr>
<tr>
<td>V₅</td>
<td>Horizontally even with V₄, but in the anterior axillary line. (The anterior axillary line is the imaginary line that runs down from the point midway between the middle of the clavicle and the lateral end of the clavicle; the lateral end of the collarbone is the end closer to the arm.)</td>
</tr>
<tr>
<td>V₆</td>
<td>Horizontally even with V₄ and V₅ in the midaxillary line. (The midaxillary line is the imaginary line that extends down from the middle of the patient’s armpit.)</td>
</tr>
</tbody>
</table>
determined with gated SPECT have been limited to systolic indices. Therefore, we evaluated left ventricular diastolic function with gated SPECT using data obtained from various frames per cardiac cycle and found that data generated from 32-frames are suitable for clinical use. Serial assessment of left ventricular function was also performed during bicycle exercise and dobutamine stress by means of gated SPECT using short-time data collection. These techniques, therefore, have the potential to provide useful information for evaluating myocardial conditions, such as hibernation and residual ischemia in infarct areas. Recently, we have developed a new technique for three-dimensional registration of CT coronary angiography (CTCA) and ECG-gated myocardial perfusion SPECT. This technique of registration may assist the integration of information from gated SPECT and CTCA and may have clinical application for the diagnosis of ischemic heart disease. These various applications would contribute to the development of nuclear cardiology. Initial electrophysiological assessment and radiofrequency ablation can be abbreviated when accurate localization of the accessory pathway is available before the procedure. Several criteria have been previously proposed for localization of accessory pathways from the surface electrocardiogram. Rosenbaum classified ECG of patients with pre excitation but did not include sepal connections. Gallagher based their analysis on surgical ablation identified 10 locations around the tricuspid and mitral valve and the septum. The thoracic cycle electrocardiogram identified correctly the pre excitation location and its very useful for the differential diagnosis between right on left pathway, particularly in the posterior septal region. We also chose leads III, V1 and V2 to analyse the frontal and horizontal planes of the heart activation and we could easily identify the sites of right and left pre excitation. With our algorithm, we were able to correctly identify the location of the accessory pathway in 88% of the patients, with a high success rate of the radiofrequency ablation. In connection with the serial electrocardiogram recorded by means of the limb lead, bipolar chest leads I and II and semi-unipolar chest lead were obtained on one each of 40 normal dairy cattle. The data derived from the analysis of these records can be summarized as follows: 1. In the electrocardiogram of the limb lead when the left and right olecranons and left patella were chosen for the positions of lead points, the triphasic and diphasic P wave in each lead, r type of QRS complex in lead I and R type in leads II and III, and monophasic negative and positive T waves are observed, respectively. 2. In case of the use of the bipolar chest lead I in which the left and right olecranons and withers were selected for the lead points, the triphasic P wave, qR and R type of QRS complex and monophasic negative T waves were observed in each lead respectively. 3. When the bipolar chest lead II was employed using the withers, left shoulder blade and the apex of the heart on the left side for the lead points, W form of P wave in each lead, QR type in leads I and II, and QR, QR in lead III, and monophasic negative T wave in leads I and II, monophasic positive and diphasic waves in lead III were observed respectively. 4. In case of the use of the semi-unipolar chest lead, the waves in the lead at the upper portion of the heart showed negative P, and R type of QRS complex and negative T wave were also observed there. On the contrary in the lead at the apical portion of the heart, the positive P and QS type of QRS complex and positive T wave were traced. 5. On the basis of these experiments, the limb lead may not be suitable for clinical use in cattle because the variation of the electrical changes of the heart was not completely traced. The bipolar chest leads I and II, however, may be applicable for clinic use, for the variation of the electrical changes of the heart were apparently registered on the electrocardiogram. The semi-unipolar chest lead may be of use in the diagnosis of disorders in the heart providing that different electrodes are placed close to the heart. From the findings described above, it may be considered that the use of bipolar chest leads I and II together with semi-unipolar chest lead is valuable for the clinical diagnosis of heart disorders [30].

LIMITATIONS & RISKS

There is not enough safety information to justify exercise ECG testing in the first 2 to 3 days after a heart attack. It is safe to do a treadmill test more than 5 days after an uncomplicated heart attack,
when stress testing can help determine a safe level of activity. A negative (normal) test means you have a low risk of having another heart attack. If you are unable to perform an exercise ECG, you are at a higher risk of having another heart attack or dying from heart disease. You should also have an exercise ECG before starting cardiac rehabilitation or any type of exercise program. A normal exercise ECG is a reliable test for ruling out heart problems in women. In terms of the print out showing the heart’s electrical activity, a positive exercise ECG is less reliable for women than for men. Women are prone to false positive results the test detects a problem, but in reality there is none. Chest pain during exercise testing is also less likely to be a sign of heart disease in women than in men. Because of these limitations, you should not be referred for invasive testing such as cardiac catheterization based on a positive exercise ECG alone. The results should be confirmed through further noninvasive testing first, such as echocardiography or a nuclear stress test. However, the exercise ECG measures a lot more than just the print out of the heart’s electrical activity. It also measures your exercise capacity, and how your blood pressure and heart rate are affected by exercise. When these factors are looked at, the exercise ECG is an excellent test for predicting your risk of having a heart attack or dying from heart disease [31,32].

X-RAYS

X-rays is a form of electromagnetic radiation. X-rays have a wavelength in the range of 0.01 to 10 nanometers, corresponding to frequencies in the range 30 petahertz to 30 exahertz (3 × 10^{16} Hz to 3 × 10^{19} Hz) and energies in the range 120 eV to 120 keV. X-rays from about 0.12 to 12 keV (10 to 0.10 nm wavelength) are known as soft X-rays and from about 12 to 120 keV (0.10 to 0.01 nm wavelength) as hard X-rays, due to their penetrating abilities. Hard X-rays can penetrate solid objects, and their most common use is to take images of the inside of objects in diagnostic radiography and crystallography. The measure of X-rays ionizing ability is called the exposure. The SI unit of ionizing radiation exposure is coulomb per kilogram (C/kg) and roentgen (R). Medical X-rays are a significant source of man-made radiation exposure, accounting for 58% in the United States in 1987, but since most radiation exposure is natural (82%), medical X-rays only account for 10% of total American radiation exposure. Reported dosage due to dental X-rays seems to vary significantly. Wilhelm Rontgen, as the discoverer of X-rays. X-rays were found emanating from Crookes tubes, experimental discharge tubes invented around 1875, by scientists investigating the cathode rays that are energetic electron beams that were first created in the tubes. Crookes tubes created free electrons by ionization of the residual air in the tube by a high DC voltage of anywhere between a few kilovolts and 100 kV. This voltage accelerated the electrons coming from the cathode to a high enough velocity that they created X-rays when they struck the anode or the glass wall of the tube. Many of the early Crookes tubes undoubtedly radiated X-rays, because early researchers noticed effects that were attributable to them, as detailed below. Wilhelm Rontgen was the first to systematically study them, in 1895. Johann Hittorf (1824–1914), a co-inventor and early researcher of the crookes tube, found when he placed unexposed photographic plates near the tube, that some of them were flawed by shadows, though he did not investigate this effect. In 1877, Pulyui, constructed various designs of vacuum discharge tube to investigate their properties. In 1886 he found that sealed photographic plates became dark when exposed to the emanations from the tubes. In April 1887, Nikola Tesla began to investigate X-rays using high voltages and tubes of his own design, as well as Crookes tubes. The principle behind Tesla’s device is called the bremsstrahlung process, in which a high-energy secondary X-ray emission is produced when charged particles (such as electrons) pass through matter. X-rays were generated and detected by Fernando Sanford (1854–1948). Philipp Lenard, built a crookes tube (Lenard tube) with a window in the end made of thin aluminum, facing the cathode so the cathode rays would strike it. He found that something came through, that would expose photographic plates and cause fluorescence. He measured the penetrating power of these rays through various materials. Rontgen was investigating cathode rays with a fluorescent screen painted with barium platino cyanide and
a crookes tube which he had wrapped in black cardboard so the visible light from the tube wouldn’t interfere. He noticed a faint green glow from the screen, about 1 meter away. In 1895, Thomas Edison investigated materials’ ability to fluoresce when exposed to X-rays, and found that calcium tungstate was the most effective substance. Around March 1896, the fluoroscope he developed became the standard for medical X-ray examinations. At the 1901 Pan-American Exposition in Buffalo, New York, an assassin shot President William McKinley twice at close range with a .32 caliber revolver. The first bullet was removed but the second remained lodged somewhere in his stomach. One of the exhibits at the exposition was Edison’s new x-ray machine which he offered the use during McKinley’s surgery. The offer was declined because the x-ray machine had not been tested and approved at this point. McKinley survived for some time and requested that Thomas Edison rush an X-ray machine to Buffalo to find the stray bullet. It arrived, but was not used as McKinley died of septic shock due to bacterial infection. The first medical X-ray made in the United States was obtained using a discharge tube of Pulyui’s design. In January 1896, on reading of Rontgen’s discovery, Frank Austin of Dartmouth College tested all of the discharge tubes in the physics laboratory and found that only the Pulyui tube produced X-rays. This was a result of Pulyui’s inclusion of an oblique target of mica, used for holding samples of fluorescent material, within the tube. On 3 February 1896 Gilman Frost, professor of medicine at the college, and his brother Edwin Frost, professor of physics, exposed the wrist of Eddie McCarthy, whom Edwin had treated some weeks earlier for a fracture, to the X-rays and collected the resulting image of the broken bone on gelatin photographic plates obtained from Howard Langill, a local photographer also interested in Rontgen’s work [33, 34].

APPLICATIONS OF X-RAY

Plain X-Rays

X-rays are useful in the detection of pathology of the skeletal system as well as for detecting some disease processes in soft tissue. Some notable examples are the very common chest X-ray, which can be used to identify lung diseases such as pneumonia, lung cancer or pulmonary edema, and the abdominal X-ray, which can detect intestinal obstruction, free air (from visceral perforations) and free fluid (in ascites). X-rays may also be used to detect pathology such as gallstones or kidney stones which are often visible. Traditional plain X-rays are less useful in the imaging of soft tissues such as the brain or muscle.

Fluoroscopy

Fluoroscopy is another X-ray test methodology. This method may use a contrast material. Examples include cardiac catheterization (to examine for coronary artery blockages) and Barium swallow (to examine for esophageal disorders).

Radiotherapy

The use of X-rays as a treatment is known as radiation therapy and is largely used for the
management (including palliation) of cancer; it requires higher radiation energies than for imaging alone.

Other Notable Uses of x-rays Include
X-ray crystallography in which the pattern produced by the diffraction of X-rays through the closely spaced lattice of atoms in a crystal is recorded and then analysed to reveal the nature of that lattice. Discover the double helical structure of DNA. X-ray microscopic analysis, which uses electromagnetic radiation in the soft X-ray band to produce images of very small objects. X-ray fluorescence, a technique in which X-rays are generated within a specimen and detected. The outgoing energy of the X-ray can be used to identify the composition of the sample. Industrial radiography uses X-rays for inspection of industrial parts, particularly welds. Paintings are often X-rayed to reveal the under drawing and pentimenti or alterations in the course of painting, or by later restorers. Many pigments such as lead white show well in X-ray photographs. Airport security luggage scanners use X-rays for inspecting the interior of luggage for security threats before loading on aircraft. Border security truck scanners use X-rays for inspecting the interior of trucks for at country borders. X-ray fine art photography. Roentgen Stereophotogrammetry is used to track movement of bones based on the implantation of markers. X-ray photoelectron spectroscopy is a chemical analysis technique relying on the photoelectric effect, usually employed in surface science [36].

LIMITATIONS OF X-RAY
The X-ray is invaluable as an aid in the diagnosis of many bone and joint diseases. The roentgenogram is pathognomonic of some diseases. There are different diseases in which the roentgenograms are similar, and the diagnosis must be made with the aid of the clinical data. The X-ray is not of great value in the early diagnosis of certain pathological conditions of bones and joints, e.g., tuberculosis and acute infectious osteomyelitis, because changes in structure (density), of the bone have not been produced. The X-ray does not always give us a true picture of the nature and extent of the pathological process. The limitations of the X-ray in the diagnosis of disease and extent of the pathological process are due to the fact that the roentgenogram does not show differences in the composition of substances of the same density [37].

SAFETY OF X-RAYS
As with other medical procedures, x-rays are safe when used with care. Radiologists and x-ray technologists have been trained to use the minimum amount of radiation necessary to obtain the needed results. Properly conducted imaging carries minimal risks and should be performed when clinically indicated. The amount of radiation used in most examinations is very small and the benefits greatly outweigh the risk of harm. X-rays are produced only when a switch is momentarily turned on. As with visible light, no radiation remains after the switch is turned off.

COMPARISON BETWEEN DIFFERENT BIOMEDICAL DIAGNOSTIC TECHNIQUES

CT SCAN VS. MRI
The basic mathematics of the 2D-fourier transform in CT reconstruction is very similar to the 2D-FT in MRI, but the computer data processing in CT does differ in detail, as for example in the case of the volume rendering and artefact elimination algorithms that are specific to CT. Although CT is a relatively accurate test, it is liable to produce artifacts, such as the following:

Aliasing Artifact or Streaks
These appear as dark lines which radiate away from sharp corners. It occurs because it is impossible for the scanner to sample or take enough projections of the object, which is usually metallic. It can also occur when an insufficient X-ray tube current is selected, and insufficient penetration of the x-ray occurs. These artifacts are also closely tied to motion during a scan. This type of artifact commonly occurs in head images around the pituitary fossa area.

Partial Volume Effect
This appears as blurring over sharp edges. It is due to the scanner being unable to differentiate
between a small amount of high-density material (bone) and a larger amount of lower density (cartilage). The processor tries to average out the two densities or structures, and information is lost. This can be partially overcome by scanning using thinner slices.

**Ring Artifact**
Probably the most common mechanical artifact, the image of one or many rings appears within an image. This is usually due to a detector fault.

**Noise Artifact**
This appears as graining on the image and is caused by a low signal to noise ratio. This occurs more commonly when a thin slice thickness is used. It can also occur when the power supplied to the X-ray tube is insufficient to penetrate the anatomy.

**Motion Artifact**
This is seen as blurring and/or streaking which is caused by movement of the object being imaged.

**Windmill**
Streaking appearances can occur when the detectors intersect the reconstruction plane. This can be reduced with filters or a reduction in pitch.

**Beam Hardening**
This can give a cupped appearance. It occurs when there is more attenuation in the center of the object than around the edge. This is easily corrected by filtration and software [38].

**COMPARISON BETWEEN EEG VS. MRI**
EEG has several strong points as a tool for exploring brain activity. EEG’s can detect changes within a millisecond timeframe, excellent considering an action potential takes approximately 0.5-130 milliseconds to propagate across a single neuron, depending on the type of neuron. EEG measures the brain’s electrical activity directly, while other methods record changes in blood flow (MRI) or metabolic activity (PET), which are indirect markers of brain electrical activity. EEG can be used simultaneously with MRI so that high-temporal-resolution data can be recorded at the same time as high-spatial-resolution data, however, since the data derived from each occurs over a different time course, the data sets do not necessarily represent exactly the same brain activity. There are technical difficulties associated with combining these two modalities, including the need to remove the MRI gradient artifact present during MRI acquisition and the ballistocardiographic artifact from the EEG. Furthermore, currents can be induced in moving EEG electrode wires due to the magnetic field of the MRI [39].

**ECG VS EEG**
Electroencephalogram or EEG is related to the brain and electrocardiogram or ECG is related to the heart. EEG is the equipment used for measuring electrical activities of the brain. On the other hand, ECG is used for measuring activities of heart. EEG is mainly used for diagnosing seizure disorders, infections, tumors, degenerative disorders and metabolic disturbances that could affect the brain. On the contrary, ECG is used to determine the rate of heart beats; heart chamber positions and if there is any damage to heart. The ECG helps in determining if a person has any problems of the heart. Both the ECG and the EEG uses electrodes for determining electric impulses of the heart and the brain. In EEG, the electrodes are attached to the scalp. But for taking ECG, the electrodes are attached to the chest, legs, arms and neck. While about 16 to 20 electrodes are used in EEG testing, about 12 electrodes are used in ECG testing. While ECG testing involves no risks or pain the EEG testing comes with certain adverse conditions. People having seizures who undergo an EEG test can experience seizures at the flash of lights [40].

**X-RAY VS. MRI**
The main differences between an x-ray and an MRI are the images they produce. An x-ray clearly shows the contrast between soft tissue and bone density. That is why it is often used to examine broken bones. An MRI image shows a better
contrast between different kinds of soft issue. That is why it produces such detailed images of the brain and other tissues. When X-Rays were discovered they represented an amazing medical breakthrough in non-evasive examination, and in some ways they still do. They allow doctors to examine a patient without surgery, and therefore in a much safer manner. X-ray’s are so powerful; they have the ability to knock electrons off of the atoms they hit. This produces ions, or negative atoms that produce abnormal chemical reactions in the body. X-rays can also alter DNA. The resulting mutations often lead to birth defects or disease. MRI is more versatile than x-ray also, as it can be used to examine a wider variety of medical conditions. MRI does have a few disadvantages though. People who are claustrophobic have difficulties staying in the enclosed area. Some hospitals have open MRI machines that limit the amount of enclosed area. However, for patients with extreme claustrophobia, even an MRI in an open machine is too much to handle [41].

X–RAY VS. CT SCAN

The CT scans are highly sensitive in detecting disease in soft body tissues and can actually provide images of internal organs which are impossible to visualize with an x-ray technique. Using CT guidance, biopsy, excision or ablation procedures could safely be performed. The imaging effects or biological effects of x-rays can cause tissue cell injured or even cell death. So X-ray is doubled edged sword; in x-ray therapy it can help kill cancerous cells, at the same time it can damage normal body cells. Thus we must use x-rays in a proper way and pay attention to protect patient as well as ourselves from high doses of x-rays exposure. X-Rays used in CT scans usually have no harms. CT scan is a more developed version of x-ray to mainly focus on specific parts of body. CT scan has additional advantage of being able to produce imaging virtually in any orientation. CT scans provide better images for bones structures, inner ear as it can easily detect tumors in the auditory canal and cochlea. CT scans help diagnose bone tumors, bone fractures, internal injuries, internal bleeding & blood clot and to monitor cancer and heart diseases.

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