RADIOLOGY – A SUPPORT FOR THE MODERN CLINICIAN

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Abstract

Radiology in medicine was initiated over a century ago with the invention of X-ray by Roentgen. The last twenty five years have shown extensive advancements in the field of medicine. Development of radiology has however not aided the clinician due to proper understanding of the various radiological facilities currently available. Interventional radiology has become the better alternative than surgery for many infective, non infective and malignant conditions. This lecture attempts to highlight the recent advancement in radiological procedures and stress upon the continued relevance of various age old procedures like Barium meal, barium enema, intra venous urogram and the like compared to the modern sophisticated investigations like CT scan, MRI scan and PET scan. Radio frequency waves have come handy for the treatment of varicose veins and certain types of early malignancy. Ultra sound scan is recognized to be better in assessing rectal malignancy. Percutaneous drainage of urine and other secretions have helped minimizing surgical incisions. With these advancements, radiology has become clinician friendly.

Keywords: radiology, x-ray, ultra sound, ct scan, mri scan, pet scan.

Full text, with all subsections and illustrations.

INTRODUCTION

Investigations are tests conducted in the laboratory or ward to confirm or exclude a clinical diagnosis. They may be invasive (when there is a needle or other instrumental penetration into the body) or non invasive. Invasive procedures include blood examination, IVU, IV Contrast CT, Contrast MRI, FNAC, Biopsy, Laparoscopy, Laparotomy etc. Non invasive procedures include urine examination, ultra sound study, plain x-ray, barium studies etc.

ULTRA SOUND

Sound waves with high pitches become less audible. Sound wave of more than 20 KHz. (20,000 Hz.) frequency is called ULTRA SOUND. This sound wave can pass through body tissues and reflect when hitting against any obstacle. The reflected waves can be recorded on a screen through “a mode”, “b mode”, “m mode” or “real time” sonograms. In diagnostic ultra sound, sound waves of 2.5 to 15 Mhz frequency are passed through a transducer and the reflected patterns are recorded on a television screen and photographed. Lower frequencies of 3-5 MHz are usually used for ultra sound scanning and real time imaging is recorded. This will penetrate tissues well, but the picture resolution will be less sharp. For duplex (colour Doppler) ultra sound scan, higher frequencies of sound waves namely 7 to 10 MHz are used. High resolution Doppler scan may be 12 to 20 MHz.

| FREQUENCY OF US SCAN IS 3 MHz to 5 MHz . |
| It differentiates between solids and cysts. |
| FREQUENCY OF COLOUR DOPPLER US SCAN IS 7 MHz to 10 MHz . |
| It identifies direction of blood flow. Flow towards the probe will appear as red and flow away from the probe will appear as blue. |
| FREQUENCY OF HIGH RESOLUTION US SCAN IS 12 MHz to 20 MHz. |
| It recognizes vascularity of tissues / tumours. |

Various normal USS pictures are shown below. The first lesson of USS is that it differentiates
liquid from solid organs like liver and kidney. The kidney appears less dense than the liver. The pancreas can be recognized as a solid structure behind the stomach. The kidney can be visualized by placing the probe at appropriate positions. The length, breadth and cortical thickness can be accurately measured in USS. A full bladder is easily recognized by the non echogenic appearance of urine. A Foley’s catheter is easily recognized because of the bulb filled with water. The prostate is seen behind the bladder and its dimensions can be easily measured. From the dimensions, the weight is calculated and reported. The testes is clearly recognized as a solid structure surrounded by fluid in the tunica vaginalis sac in the scrotum. USS is done for assessing the thyroid, breast lumps, soft tissue masses, abscesses, haematomas, hernias etc. USS done for the heart is called echocardiography, which is done to assess cardiac function and valvular blood flow patterns.

X-RAY

X-ray investigation is performed to study the x-ray penetrability of the tissues under investigation. The films are usually negative. Bone is radio opaque and appears as white, whereas air is radiolucent and appears as black. Soft tissues and fluids have different ranges of radio opacity. For the study of bones, the intensity of x-ray penetration is more; for the study of soft tissues like mammography, low intensity x-rays are used. X-rays can be plain pictures or contrast picture.

X-rays can be taken in AP view, PA view, lateral view or oblique view. In AP view (antero-posterior view), the x-rays pass from the front of the patient to the back and the film is kept in the back and the posterior structures will be clear. Eg. Spine, KUB (kidney, ureter, bladder) region, ribs etc. In PA view, x-rays pass from posterior to anterior. The film is kept in the front and anterior structures will be clear in this film. Eg. chest x-ray for lungs and diaphragm, abdomen x-ray for intestines. Lateral view is taken with the film on the side required to be studied. Eg. Skull, hydro/ haemopneumothorax, fracture of bones, dislocations etc. Special positions may be used for special situations. Eg. Towne’s view or occipito mental view for paranasal sinuses. It is possible to focus at the depth of tissues, when it called a tomogram. For getting a clear view of the mandible, special x-ray source is kept in the sub mental region and special picture called "orthopantomogram" is taken. Low penetration x-rays are used for demonstrating soft tissues like breast, called mammogram.

When contrast is administered, it is called a contrast x- ray. Barium swallow, barium meal, barium enema, intra venous urogram, pyelogram (antgrade/ retrograde), cystogram, urethrogram, micturating cysto urethrogram, cholecystogram, cholangiogram, aortogram, arteriogram, carotid angiogram, venogram (phlebogram), lymphangiogram, sinusogram, fistulogram, myelogram, sialogram, nephrogram, hystero salpingogram, seminal vesiculogram etc are contrast studies. Contrasts include barium sulphate for recognizing anatomy and pathology of the gastro intestinal tract, telepaque (iopanoic acid) for oral cholecystogram, biligrafin or adipiodone for intra venous cholecystangiogram, sodium iothalamate (conray) 420, uromiro, ultravist (non-ionic), lohexol (Omnipaque) 300 mg (50 ml), Ioversol 300 mg (50 ml) etc. for intra venous pyelogram, retrograde pyelogram, antegrade pyelogram, cystogram, cysto urethrogram, aortogram, arteriogram, venogram, lipiodol for sialogram, myelogram, sinusogram or fistulogram, thin barium (cremobar) for bronchogram etc. Sometimes air can also be introduced along with the contrast to create double contrast films. This is useful in colonic pathology like diverticulosis and multiple polyposis coli and bladder tumours. Presacral air insufflation studies are used to assess adrenal tumours. Pneumoencephalogram is performed to study the ventricles of the brain.

Digital subtraction x-ray is a newer modality of investigation. Here a positive film and a negative film are superimposed on each other and a picture is taken. After taking the first x-ray, contrast is injected and the second is taken. So the superimposed film will show only the portion containing the dye. This is useful for angiograms (DSA-digital subtraction angiogram), barium studies and all other situations using contrast.

C.T. SCAN

Historical:

It was in 1895 that Roentgen invented the x-rays. During the 1940s, Tomograms were started to be used and in 1960s, Hounsfield started computerised tomography which paved the way for the present day CT scans.
Principles:
X-ray source
X-ray detector
Each small field (pixel) is assigned a number (Hounsfield unit) (Air is -1000 H.U.; Water is zero H.U.; Bone is +1000 H.U.)

Procedure: Plain CT (Scanogram / scout film / Non Contrast Enhancement CT – NCECT) and enhanced (Contrast Enhancement CT – CECT) after administering non ionic contrast – Ultravist 300 mg (50 ml), Ioversol 300 mg in 50 ml or Iohexol (Omnipaque) 300 mg in 50 ml intravenously.
Supine position or suspended position. Scan thickness is 2/4/8 mm and slice interval - 15 mm
Number of scans - 4 to 40
Time - 0.5 to 2 hours.
Advantages: Small pathology can be identified for an accurate diagnosis. Radiation is similar to intravenous pyelogram

Clinical Uses:
Brain: Tumour, infarct, bleeding, abscess, air bubbles probably due to antral injury and hydrocephalus
Neck: Thyroid
Chest: Lung tumour, Pleural effusion, fractured ribs, secondary deposits in lymph nodes.
Abdomen: Liver - Abscess, cyst, secondaries, primary
Pancreas - Carcinoma, pancreatitis, stone
Retropertitoneal tumours
Kidney - stone, hydronephrosis, tumours
Bladder - stone, carcinoma
Prostate - benign enlargement, carcinoma

Bones: Fractures, tumours, abscesses
Soft Tissues: Tumours, lymph nodes
Special: Interventional CT, CT-guided biopsy, CT-guided drainage

CT SCAN INTENSITY IS MEASURED IN HOUNSFIELD UNITS. AIR IS -1000 HU, WATER IS 0 HU AND BONE IS +1,000 HU

NMRI-NUCLEAR MAGNETIC RESONANCE IMAGING

NMRI is the analogue representation of the digital images emanating from the tissues when the radio frequency waves to which they are exposed are suddenly withdrawn, while the body is under a constant electromagnetic field. This was first used in humans in 1972.

In order to understand the principles of NMR, some basic physics is to be understood. The atom is composed of a nucleus containing protons and neutrons with electrons in the outer shells. Protons and neutrons are equal in number usually. When there is a disparity in this number, the atom becomes an ion. The living body contains several ions, namely hydrogen, calcium, magnesium, chloride, bicarbonate etc. Hydrogen ion is the most predominant and is considered in the further discussions. Ions are considered as paramagnets. They have weak magnetic property and hence occupy a specific position, when subjected to a magnetic field. While ions are in such a field, if they are exposed to a radio-frequency wave, they absorb energy and change direction, which is called a spin. When the radio-frequency wave is abruptly stopped, the ion spins back to its original position releasing the absorbed electrical energy. This energy which is digital is converted into analogue image by the computer and is recorded as NMR images. The main parts of the equipment are a superconductive magnet to produce the electromagnetic field, the radio-frequency coils, which transmit and receive energy waves, digital storage unit and computer display. The pictures recorded are classified as T1 weighted (longitudinal spin lattice relaxation time- Inversion Recovery sequence) and T2 weighted (Spin-spin lattice relaxation time- Spin Echo sequence) image. Images with high MR signals appear white (soft tissues with high proton density and slow blood flow) and images with low MR signals appear black (bone, air). T1 weighted images show white images when there is short longitudinal Inversion Recovery time and hence fast recovery. T2 images show white image in long transverse spin echo time (slow recovery). T1 weighted images are useful for differentiating soft tissues, bone, air, fat, fluids etc., where the left hand picture shows the T1 weighted image with black CSF and white spinal cord, whereas the right side film, which is showing a T2 weighted image does not show this contrastingly. T2
weighted images are useful to detect pathological changes in the tissues. Special pictures are taken to get clearer views of tissues, the common one is STIR (Sagital short Tau Inversion Recovery image). The basic understanding of MRI scan is based on “water is black in T1, white in T2 and bright in STIR”.

**POSITRON EMISSION TOMOGRAPHY (PET).**

This is a new metabolic imaging for organs. It is a nuclear medicine molecular imaging technique. Positrons are positively charged particles like electrons. They combine with electrons and emit gamma rays, which can be recorded on a monitor. This emission has been found to be different in different viable tissues. Hence it is very useful to identify malignancies and differentiate between benign and malignant conditions. PET in combination with CT has demonstrated added capability to differentiate between pathology and normal physiological tracer uptake. It is thus useful for detecting early cancer.

**Author’s biography (200 words) BIO DATA OF DR. Y.M. FAZIL MARICKAR**

Dr. Fazil Marickar MS, MAMS, PhD (Urology), FAMS, FIMSA, FAS, FEMSI is Principal, Mount Zion Medical College. He is surgical teacher for 43 years and has done extensive research on urolithiasis, completed 42 funded research projects of the ICMR, CSIR etc., presented 130 international and 850 national papers and published 389 papers and seven books. He has guided eleven Ph.Ds. He delivered the Pandalai Oration of ASI and was the first doctor to receive the Fellowship of the Electron Microscopic Society of India and Indian member of the International Consulting Committee on Urolithiasis. He is Inspector of MCI expert panelist of the Kerala State Council for Science, Technology and Environment. He was the best doctor of Kerala in 2000. He is President of Association of British scholars, Secretary of NAMS, Governing Council Member of ASI, Editorial Board Member of Urological Research and peer reviewer for many international journals. He was nodal officer medical curriculum for Kerala, Chairman of the ASI Kerala Chapter, President of ASI Trivandrum branch, Vice President of Urolithiasis Society of India, Secretary of Urological Association of Kerala, Editorial Secretary of Urolithiasis Society of India and editor of Kerala Surgical Journal.

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