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“MRI: A Magnificent Tool in the Diagnosis of Diverse Diseases”.

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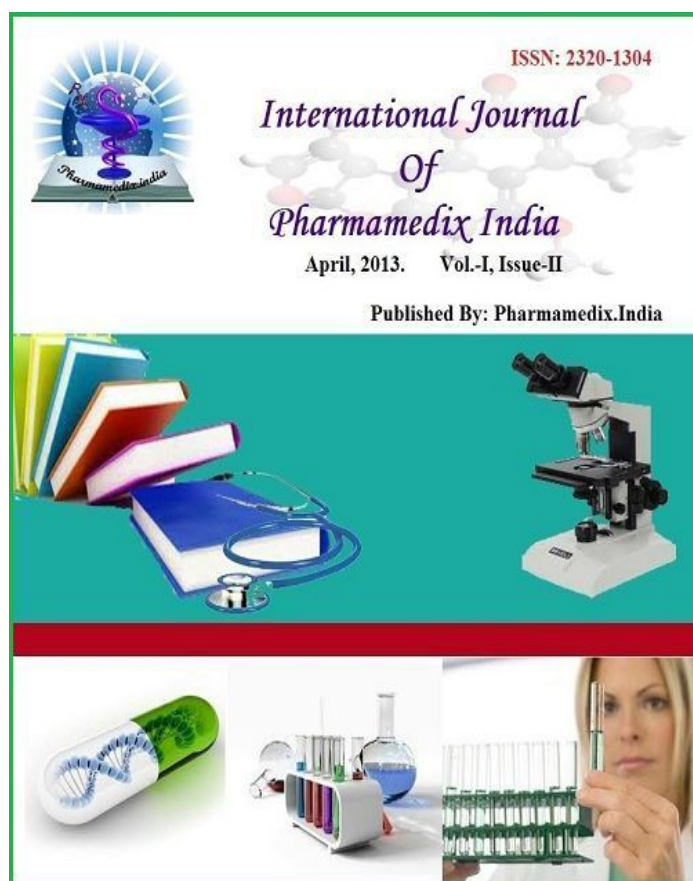
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Abstract:

Today, the use of Magnetic Resonance Imaging (MRI) scanners has grown tremendously. Doctors may order MRI scans to help diagnose multiple sclerosis, brain tumors, torn ligaments, tendonitis, cancer, strokes and a number of other ailments which a person come across in his daily life. An MRI scan is the best way to see inside the human body without cutting it open. Magnetic resonance imaging (MRI) is a non-invasive way to take pictures of the body. Unlike X-rays and computed tomographic (CT) scans, which use radiation, MRI uses powerful magnets and radio waves. The magnetic field produced by an MRI is about 10 thousand times greater than the earth's magnetic field. Single MRI images are called slices and these images can be stored on a computer or printed on film. One exam produces dozens or sometimes hundreds of images. This review describes various aspects like principle, construction, working, applications of MRI which will be very beneficial for the researchers and health professionals.

Keywords: MRI, Radiofrequency waves, Magnetic field.

Introduction:

MRI (Magnetic Resonance Imaging) is a type of medical imaging technology that uses magnetic fields and mainly useful in neurological (brain), musculoskeletal, cardiovascular and oncological (cancer) imaging. MRI provides much greater contrast between the different soft tissues of the body than computed tomography (CT). To produce an MRI image, the patient's body is placed in a strong magnetic field. This makes certain atoms in the body produce signals that can be detected by special radio equipment in the

MRI machine. A computer then creates an image of the part of the body under study^[1].

ALTERNATIVE NAMES Magnetic Resonance Imaging (MRI), Nuclear Magnetic Resonance Imaging (NMRI).

PRINCIPLE OF MRI

It is based on the observation of water molecules (protons to be exact) in the human body. As an external static magnetic field applied, the protons of water molecules will be aligned with the magnetic field as magnetic dipoles^[2]. When they are disturbed by a second alternating magnetic field, at certain radio frequency, they begin to

resonate. According to Faraday's law, the processing of magnetic dipoles induces electric currents, giving rise to signals, in a copper coil (called a probe) surrounding them^[3]. The magnetic field strength used in most clinical MRI units is 1.5 Tesla. The corresponding precession frequency of the protons is 64 MHz's. The signals are detected in high radio frequency (RF), but transformed into lower audio frequency ranged for sampling, recording, and analyses^[4].

CONSTRUCTION OF MRI

The traditional MRI unit is a large cylinder-shaped tube surrounded by a circular magnet. Patient will lie on a moveable examination table that slides into the centre of the magnet. Some MRI units, called short-bore systems, are designed so that the magnet does not completely surround the patient; others are open on the sides (open MRI).

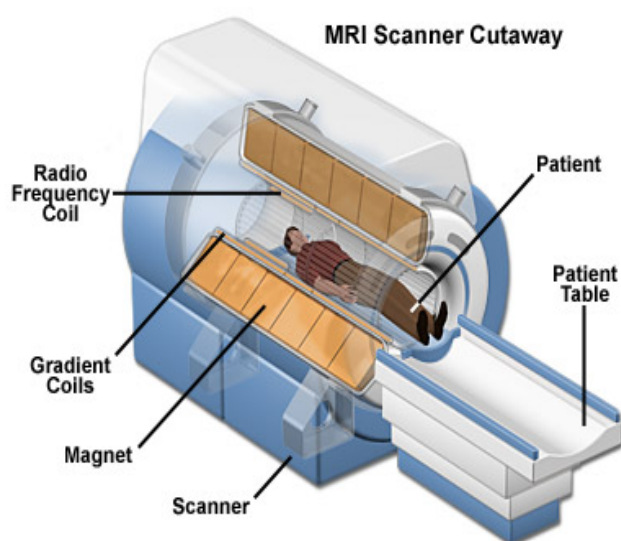


Fig.1 Various parts of MRI



Fig.2 Magnetic Resonance Imaging

These units are especially helpful for examining patients who are fearful of being in a closed space and for those who are very obese. Newer open MRI units provide very high quality images for many types of exams; however, open MRI units with older magnets may not provide this same quality. The computer workstation that processes the imaging information is located in a separate room than the scanner (Figure 1& 2)^[5].

WORKING OF MRI

The three basic components of the MRI machine are as:

1. The Primary Magnet

It is the largest part of the MRI. Developing a magnetic field of adequate strength to create MRI images was an early hurdle to overcome in the development of this technology. A permanent magnet powerful enough to use in a MRI would be too costly to produce and too

cumbersome to store. The other way to make a magnet is to coil electrical wire and run a current through the wire. This creates a magnetic field within the center of the coil. In order to create a strong enough magnetic field to perform MRI, the coils of wire must have no resistance; therefore they are bathed in liquid helium at a temperature 450 degrees Fahrenheit below zero! This allows the coils to develop magnetic fields of 1.5 to 3 Tesla (the strength of most medical MRIs), more than 20,000 times stronger than the earth's magnetic field.

2. The gradient magnets

These are the 'fine-tuning' part of the MRI machine. They allow the MRI to focus on a specific part of the body and also responsible for the 'clanging' noise in a MRI. There are three smaller magnets within a MRI machine called gradient magnets. These magnets are much smaller than the primary magnet (about 1/1000 as strong), but they allow the magnetic field to be altered very precisely. It is these gradient magnets that allow image "slices" of the body to be created. By altering the gradient magnets, the magnetic field can be specifically focused on a selected part of the body.

3. The coil

There are coils made for shoulders, knees, and other body parts. The coil will emit a radiofrequency that makes a MRI possible.

MRI uses properties of hydrogen atoms to distinguish between different tissues within the human body. The human body is composed primarily of hydrogen atoms (63%), other common elements are oxygen (26%), carbon (9%), nitrogen (1%), and relatively small amounts of phosphorus, calcium, and sodium. MRI uses a property of atoms called "spin" to distinguish differences between tissues such as muscle, fat, and tendon.

With a patient in a MRI machine, and the magnet turned on, the nuclei of the hydrogen atoms tend to spin in one of two directions. These hydrogen atom nuclei can transition their spin orientation, or process, to the opposite orientation. In order to spin the other direction, the coil emits a radiofrequency (RF) that causes this transition (the frequency of energy required to make this transition is specific, and called the Larmour Frequency).

The signal that is used in creating MRI images is derived from the energy released by molecules transitioning, or processing, from their high-energy to their low-energy state. This exchange of energy between spin states is called resonance, and thus the name magnetic resonance imaging ^[6].

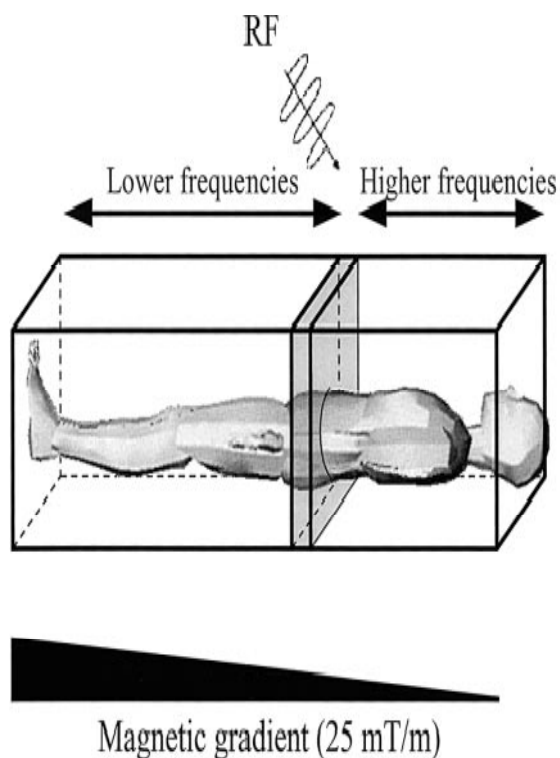


Fig.3. Single slice through the body is selected in MRI by superimposing a small magnetic gradient on the main magnetic field in cranial-caudal direction. RF pulses will only excite the spins, where the RF pulse matches the local precessing frequency determined by the Larmor equation [2].

APPLICATIONS OF MRI

MRIs are a relatively new technology to hit the medical world, and have completely revolutionized medical imaging and the diagnosing process too. In-vivo images can be taken of the human body, meaning that internal images can be seen without making any incisions.

1. Brain

Magnetic resonance imaging (MRI) multispectral segmentation methods have been proposed for the determination of the volume of normal brain tissues (e.g., white or gray matter), multiple sclerosis (MS) lesions, and tumor volume [7]. Typical indications for a MRI of the brain include headaches, dizziness, visual changes, hearing loss, seizures, nausea, history of cancer, auto-immune disease, and tingling or numbness in extremities [8]. MRI of the brain can help to detect tumors and other lesions, metabolic disorders, and multiple sclerosis or other demyelinating processes [9].

2. Neck

MRI allows for better assessing the inner soft tissue structures of the neck, like muscles, subcutaneous tissue and lymph nodes; but even vessels and the larynx can be judged adequately [10]. MRI helps distinguish differences between lymph nodes and blood vessels. Typical indications for a MRI of the neck include enlarged lymph nodes or a palpable mass [11].

3. Spine

MRI is the method of choice as spinal cord imaging procedure in almost all age groups, usually following plain film radiographs. A wide range of diseases can be diagnosed and – due to the non-invasive nature of MRI –

follow-up investigations can be performed trustfully without exposing patients to radiation, too. Only in neonates and young infants spinal US should be performed as the first imaging approach. Typical indications for a MRI of the spine include back pain, numbness or tingling in extremities, history of cancer, and loss of bladder or bowel control. MRI of the spine can help detect herniated or bulging discs, arthritic changes, tumors and other lesions, differences between a post operative scar or recurrent disc, and structural abnormalities ^[12].

4. Thorax

In the past, it was difficult to obtain diagnostic pictures of the thorax with MRI due to heart and breathing motion. However, MRI has improved its capability to take pictures by using a set of cardiac leads to monitor heart rhythms and acquire pictures with a "snapshot" eliminating heart motion. Breath-hold imaging utilizes ultrafast techniques while a patient holds his/her breath to acquire motion free pictures. Typical indications for a MRI of the Thorax include history of cancer and a questionable mass. MRI of the Thorax can help detect metastatic disease, aortic aneurysms, and aortic dissections. Continuous advances in MRI sequences have made it possible to obtain high quality anatomical images of the thoracic cavity. Black and bright-blood MRI methods

have evolved into practical tools for illustration of the thoracic vessels ^[13].

5. Cardiac

MRI has been shown to be an accurate and reproducible tool for the assessment of left and right ventricular (RV) measurements ^[14]. The information that can be obtained in a single examination includes ventricular volumes, mass and ejection fraction (EF) which provide both diagnostic and prognostic information ^[15].

6. Breast

MRI's ability to differentiate water, fat, and silicone makes it the procedure of choice for evaluating silicone breast implants or residual silicone from removed implants. Breast conserving treatment (BCT), comprising breast conserving surgery (BCS) plus radiation therapy, is equally effective to mastectomy, in terms of survival, for early-stage cancers ^[16]. MRI has a superior sensitivity compared with mammography in assessing index tumor size. The advantage of MRI relative to mammography has been shown to be non-significant in fatty breasts, while significant in scattered fibroglandular and heterogeneously or extremely dense breasts ^[17].

7. Abdomen

MRI was initially used in children mainly for neuroradiological applications, it has in the past years increasingly and successfully been applied to a number of paediatric abdominal conditions. MRI is increasingly used to evaluate the liver, spleen, kidneys, and pancreas. Typical indications for a MRI of the abdomen include history of cancer, pain, loss of organ function, bleeding, cirrhosis of the liver, and hepatitis. MRI of the abdomen can help detect enlarged lymph nodes, metastatic disease, tumors and other lesions, aneurysms, and structural abnormalities ^[18].

8. Pelvis

Magnetic resonance imaging (MRI) has emerged as an important diagnostic tool in the evaluation of pelvic disease and has assumed a primary role in the local staging of primary and recurrent pelvic malignancies. The two main advantages in the clinical use of MRI are excellent soft tissue contrast resolution and multiplanar imaging capability. New equipment (coils) now available greatly improves imaging in the pelvis. In women, MRI of the pelvis is increasingly used to evaluate the uterus, cervix, ovaries, bladder, fetus, and placenta. In men, MRI of the pelvis is increasingly used to evaluate the prostate, bladder, penis, and scrotum. Typical indications for a MRI of the pelvis include cancer staging, pain, palpable masses, and

pregnancy complications. MRI of the pelvis can help detect enlarged lymph nodes, fibroids, ovarian masses, prostate cancer staging, metastatic disease, testicular cancer, and structural abnormalities ^[19].

9. Musculoskeletal

The musculoskeletal system exhibits a complex geometry, difficult to model realistically, a complicated mechanical behaviour (viscoelastic, anisotropic, hyper elastic and non-linear), and complex interactions (e.g. confined cartilages within articulations). MRI is a flexible modality for imaging both soft and bony tissues non-invasively, and has been chosen in this study ^[20].

10. MR Angiography (MRA)

Magnetic resonance angiography (MRA), as a more recent development in MRI, uses tailored acquisition sequences to highlight blood flow and is widely used to assist in the management of patients with vascular diseases, especially in the brain. In many vascular beds like peripheral vessels, however, noncontrast MRA is not used routinely in clinical practice due to shortcomings of unenhanced MRA and/or the limitations of conventional extracellular MR contrast agents ^[21].

CONCLUSION

Now a day diseases are going to be increased tremendously, so diagnosis plays a very important role in the identification of correct disease. There are a lot of diseases which may have similar symptoms which can only be identified with the help of diagnostic equipments such as MRI by studying internal parts or mechanism of the body. Thus MRI plays a very important role for health professionals and patients.

COMPETING INTERESTS

The authors declare that they have no competing interests.

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