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The Technology of Magnetic Resonance Imaging (MRI) and its Uses

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Abstract:

Problem of the study: - In this research we will deal with the study of the resonance device used in medical imaging, where the resonance examination is performed from (- 20-90) minutes, where this examination is carried out by specialists in the field of medical imaging and the examination process is carried out safely and there is no great risk in this examination as long as we adhere to the examination conditions The magnetic resonance examination is performed by the patient lying inside the device where the patient is exposed to a magnetic field that works to organize the hydrogen atoms in the patient's body and radio waves emit weak signals and through this, cross-sectional images of the organ to be examined, as well as three-dimensional images can be obtained. Through our research, we aim to shed light in detail on the magnetic resonance device and how to conduct its examinations, as well as working to develop everything related to this type of MRI scans to obtain accurate examinations. The doctor asks the patient to have an MRI scan in the following cases : Examination of organs inside the chest or abdomen such as: Imaging of the heart, lungs, liver, spleen, spleen, pancreas, kidneys, or Pancreas, kidneys, pancreas, or adrenal glands. Examination of pelvic organs such as the urinary bladder . and reproductive organs such as the uterus in women and the prostate gland in men. MRI is also used to examine various tissues and organs of the body, and there are many There are many reasons to perform an MRI, the most important of which are the brain and spinal cord, and it is used to detect It is used to detect the following: Brain aneurysms. Eye disorders. Ear disorders internal organs.

Introduction

Magnetic resonance imaging (MRI) is one of the medical imaging methods used to visualize pathological changes 1,2].This technique relies on magnetic fields and radio waves [3] . There are many non-medical uses for MRI, which we will discuss at a glance. The idea of magnetic resonance began in 1945 when scientist Felix Bloch and Edward Purcell received the Nobel Prize for his discovery of magnetic resonance received the Nobel Prize for his discovery of magnetic

resonance, and was then developed by scientist Erwin Hahn in 1950 AD, then the British and American scientists Peter Mansfield and Paul Waterbury developed it for medical use [4,5]. In 1973, the first MRI of a finger section was published, and in 1977, the first In 1977, the first full-body MRI was published, and MRI was first used in chemical laboratories. Nuclear magnetic resonance was initially named after the nucleus of the atom rather than the nuclear rays themselves[6,7]. The idea of magnetic resonance The work of magnetic resonance depends on stimulating the protons in the atoms of the elements in the body to release the signal and then capture it, determine its location in the body, and display it on the gray color scale, and each scale indicates the strength of the signal, and it is indicated that the scale varies according to the different tissues in the body, and among the most important elements that stimulate protons is hydrogen due to its abundant presence in the bodies of living organisms, which gives it more power than other elements to issue the signals necessary for magnetic resonance. It is a medical imaging method to clarify pathological changes in living tissues, as it relies on magnetic fields or in another sense (magnetic field) and radio waves to obtain an image [8,9]. Magnetic fields or in other words (magnetic field) and radio waves in order to obtain an accurate and detailed three-dimensional image. A detailed three-dimensional image that enables the researcher or doctor to see the internal parts and structures of the body or the sample to be examined .Scientifically :- Magnetic resonance imaging is a complex technology known as MRI, which is actually based on a physical phenomenon known as nuclear resonance, through which it is possible to detect the changes that occur in of certain objects as a result of damage[10,11].

1.1. MRI of Conception:-

- The idea of magnetic resonance is based on stimulating the protons in the atoms of the elements in the body to emit a signal . the body to emit a signal, then pick it up, locate it in the body and display it on a gradient of gray colors indicating of gray colors indicating the strength of the signal, and the gradient is different for different tissues in the body in the body[12] .
- The most stimulating of these elements is hydrogen due to its abundant presence in living bodies and the presence of one proton in the atomic nucleus . one proton in the atomic nucleus, which gives more power than other elements to emit .To the presence of a magnet, the source of the signals used in magnetic resonance. In addition, radio waves are used as a source to generate pulses of energy. The MRI machine visualizes details inside the patient's body with a resolution of 0.3 millimeters to form two- dimensional or three-dimensional images[13].

1.2. MRI Mechanism:-

The device is 3 meters long and 2 meters wide and has a horizontal tube that extends through a magnet. The patient lies on his back and on a special bed that slowly passes through the magnetic tube that performs the imaging process. Radio waves enter the cylinder in which the body's atoms are in a resonant state, which will be imaged, the emitter turns on the waves for a short time and this energy will be absorbed by the hydrogen atoms until it is extinguished[14] . hydrogen atoms until the transmitter turns off, at which point the hydrogen protons release the energy and this process is called the relaxation phase and this process sends a signal that will be detected or followed by the system's air, radio wave receiver, and data system, which converts this signal into digital numbers so that a computer can process it and convert it into a two- dimensional image .Note : It is not necessary for the patient to be fully inserted into the magnetic cavity, but depends on the required examination . This depends on the required examination and the device may vary in size and shape according to the type of body to be examined and imaging[15].

1.3. Types of MRI:

What is the difference between closed and open MRI and which one is better? The difference is in the part where the patient sleeps during the test, in a closed MRI you can't see outside it, as if you are in a closed box, while in an open MRI you can see what is around you, so the closed MRI may only be an issue for those who are claustrophobic, but it is not scary for normal people. Bore-Closed MRI machines are high magnetic field machines with a range of 1.5 to 3 Tesla and are closed tunnel-like machines. The high magnetic field is used to show some of the finer details. Open MRI machines use a low magnetic range between -0.23 to 0.3 Tesla. Open MRI machines are suitable for patients who cannot be examined by closed machines for some conditions such as obesity or those with severe allergies and shortness of breath. Open MRIs are an alternative to closed MRIs, but they require a longer examination time. These machines are suitable for some examinations that require standing up. These diagnostics are best suited for joints and the vertebral column. Limited- MRI machines : These machines are used to examine small, specific parts of the body such as wrists, elbows, elbows, knees, and knees. elbows and knees. These machines are not available in many centers [16,17].

2. MRI systems and parts:

An MRI machine generally has a part that gives a strong magnetic field, a part that emits radio waves to stimulate protons and pick up the signals coming from them, and the part of the gradient system . The device consists of a huge spiral electromagnet to create a magnetic field around the patient . the patient, producing a magnetic field of 2 teal, which is equivalent to 20,000 gauss. This field makes the hydrogen atoms magnetize and all of them head towards their magnetic part North and unite in one direction [18].The object is then exposed to radioactive radiation, which increases the energy of these atoms, so they will change their orientation to a certain degree, leaving us with one in a million atoms for the MRI process. which is a large enough number of atoms to show a clear image of the part to be imaged and emit an inverse amount of energy. This reverse energy is received by the machine and calculated This image shows the intensity of hydrogen in each region of the body . Through this image, doctors are able to detect many diseases[19].

2.1. MRI physics:-

When atoms in the body are excited, protons move with and against the direction of the magnetic field . The amount of protons aligned with the main direction of the magnetic field is small, but very important in obtaining the image . very important in obtaining the image later, and these protons are especially excited by radio waves .They change their position from vertical to horizontal, but they soon return to equilibrium, but to return to equilibrium .the equilibrium position, there are two important timings:-The horizontal timing is the fastest time, which is when the protons are scattered on the horizontal axis .-Vertical timing is the time when the protons return to equilibrium . (It should be noted that the two timings occur simultaneously). The energy of a magnet used in an MRI is measured in Tesla units and is equal to 10,000 gauss . Measuring the Earth's average magnetism, it was found to be half a gauss[20].

2.2. Proton density

The number of energetic protons in a unit volume of tissue, and the density varies from tissue to tissue .The role of echo After the protons are affected by radio waves, the waves are transmitted again and return 180°, and the time between the first 90° effect and the second 180° effect is measured by the echo time[21].

2.3 large magnets

Magnets shimming system, radio signal system, staging system, operator's room, patient support

equipment, communication system, control room.

The control room: is the place where the computer is located and through which the doctor controls the variables There is a window in front of it to watch the patient and in which the image is output and processed. Storage computer-: This computer runs on a specific program called numaris, which is an acronym for nuclear magnetic resonance imaging software Some of the tasks of this program include running the Scan process and the technician can control the imaging parameters and image storage. Image Processor-: It accomplishes the tasks of creating and assembling image fragments and performs the functions of the processor . Photographer-: Displays the image . Measurement Control-: Controls radio waves, aberrations, and the data acquisition system during successive periods . Radio Signal Unit-: Includes the radio wave emitter and radio receiver . Aberration system-: Includes deflection amplifiers for the Z, Y, and X axes as well as deflection coils . Laser camera-: Produces image movies. Radiofrequency room-: A room containing a powerful magnet with a patient's table and some accompanying electronics Note-: The room must be fully decorated with steel or copper material so that it covers the walls in order not to distort the image and the rays do not come out of the room and affect the doctor and passers-by[22].

3. How to acquire an acquisition image- :

The patient is injected with a contrast material for the image acquisition process Magnetic Resonance Imaging (MRI) has a completely different function: it changes the magnetic field The localized magnetic field of the tissue being examined, and the response of normal tissue becomes different from that of tissues with disease, giving different results . An MRI image consists of several columns and rows called matrix Each column and row contains squares called pixels .The signals captured from the body are distributed to these squares so that they are arranged according to their order in the body . This mechanism relies on a gradient device that gives a slice of the body a certain signal strength. and the strength of the captured signal gives a color on the grayscale, resulting in a MRI is a grayscale image . The special resolution equation is: - Number of squares per cm = 1/square size. The contrast in the image depends on the horizontal and vertical timings and proton density and is called(internal effects (Echo time and repetition time are considered) external effects[25].

3.1. Safety in MRI:

There is no risk as in CT scans and generally no risk of radioactive ionization But MRI has certain risks, as in every medical use . The use of magnetic resonance is for diagnostic purposes such as imaging veins and arteries or imaging Neurological changes in the brain and magnetic resonance is considered the best type of imaging in clarifying tissues and body fluids as well as used to plan treatment plans based on radiation therapy .

Before an MRI scan, it is important to review the medical history and make sure that there are no previous surgeries or accidents that led to Previous surgeries or accidents that led to the presence of metals in the body, such as shrapnel, and this is confirmed through Routine general radiological examination .The patient passes through a metal detector that often gives the patient a special dye that is injected into the body[21].

3.2 First: Mechanical malfunctions:

The most important malfunctions that can occur are Failure in the movement of the hydraulic table: It may not move in the required directions due to Failure of the hydraulic oil pump that raises and lowers the table. Failure of the micro switch: Located in the table . Malfunction of the helium cooling units: where there are strainers for the helium unit that must be changed and stop the machine from working. Malfunction of the water cooling unit: Regular maintenance is required . Cleaning the filter: A high temperature appears if there is a malfunction in the filter . Laser printer malfunction: Some mechanical calibrations are needed to repair it . Developer malfunction: Regular

maintenance is required due to dirt and buildup of the developing material that can cause poor image quality[22] .

3.3 Second/electrical malfunctions

Malfunction in the radio wave generation unit: There are several electrical malfunctions, including a malfunction in the .The vacuum tube that generates radio waves (the wicks can be hit. Malfunction of the graduation unit: The most important manifestation of which is that the image does not appear at all and the device stops automatically. There is another malfunction that affects the gradient, which is the appearance of the image in a certain direction and not appearing in the other direction. **Note:** Electrical malfunctions are rare due to the presence of the UBS unit. There is a mechanical malfunction that may lead to an electrical malfunction and the device stops working, and this work is overheating due to a malfunction in the helium cooling unit. It is the helium gas for cooling the device where it is changed once a year and that is an expensive approach . It may be on the part of the technicians, that is, not taking care and entering when operating the device[23] .

3.4 MRl Advantages:

Imaging any part of the human body without moving the patient or the device, Seeing the inside of the human body clearly, Improving the comparison between dense and non-dense tissues and calculating their mass, Faster access to the image with the possibility of storing it ,The ability to easily modify the image to increase its accuracy to detect cancers, The possibility of transferring the image to distant places via the Internet in order to consult doctors, Does not rely on ionizing radiation, The contrast material does not give any effect on the patient's body[24]..

3.5. Disadvantages of MRI:

Despite the many benefits you get from the MRI machine, it is accompanied by some disadvantages Which is summarized in the impossibility of imaging people with a large body, as well as if there are There are metal fasteners in the body. Also, if you accidentally find a piece of metal, such as a pair of scissors or a screwdriver, the image is very distorted, in addition to that, the device makes an annoying sound during its work Due to the electric current used in generating the variable magnetic field, and the greater the magnetic field, the greater the sound . the magnetic field, the more the sound emitted, and the patient is often advised to put a waxy substance in his ears to avoid hearing the sound.

His ears to avoid hearing the sound or hearing music, and the patient must remain still for the duration of the scan, which takes 20 minutes The duration of the imaging, which takes 20 minutes and may reach 90 minutes, and any movement may cause distortion .The MRI machines are very expensive and the examination is very expensive [25].

4. MRI-diagnosed conditions

Spine Dorsal Herniated Disc: This is the least common type of herniated disc in which the fault lies in the cartilaginous discs between the thoracic vertebrae.

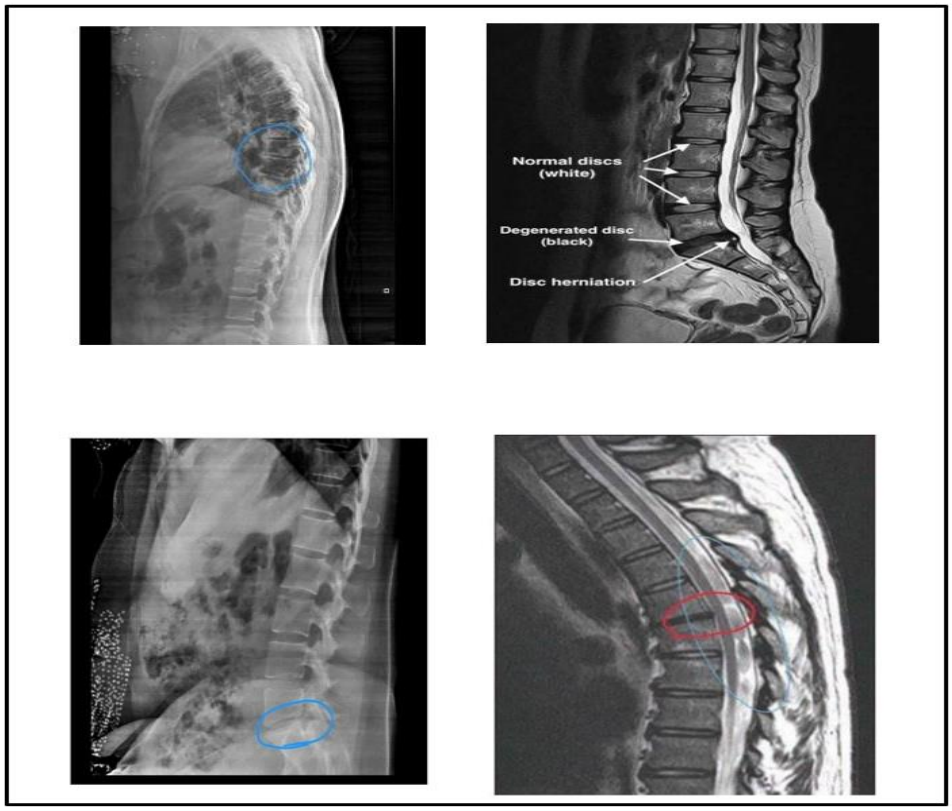

Figure (1) Lumbar Spine Lumber: This is the most common type of herniated disc. It is caused by protruding discs located between the lumbar vertebrae, causing pressure on the spinal cord. Pressure on the spinal cord.

References

1. Neurological diagnostic tests and procedures fact sheet . National Institute of Neurological Disorders and Stroke. https://www.ninds.nih.gov/Disorders/Patient-Caregiver Education/Fact-Sheets/Neurological-Diagnostic-Tests-and Procedures-Fact. Accessed July 20, 2021.
2. Magnetic resonance imaging (MRI) safety. American College of Radiology, Radiological Society of North America. https://www.radiologyinfo.org/en/info/safety-mr . Accessed July 20, 2021.
3. Chernoff D, et al. Principles of magnetic resonance imaging. https://www.uptodate.com/contents/search . Accessed July 20, 2021.
4. Tsai LL. Patient evaluation for metallic or electrical implants, devices or foreign bodies before magnetic resonance imaging. https://www.uptodate.com/contents/search. Accessed July .2021 ,20
5. AskMayoExpert. MRI of the breast. Mayo Clinic; 2021.
6. Magnetic resonance imaging (MRI). American Heart Association. https://www.heart.org/en/health-topics/heart attack/diagnosing-a-heart- attack/magnetic-resonance imaging-mri. Accessed July 20, 2021.
7. Magnetic resonance, functional (fMRI) – brain. American College of Radiology, Radiological Society of North America. https://www.radiologyinfo.org/en/info/fmribrain . Accessed July 20, 2021

8. Chakeres DW and de Vocht F. (2005) Static magnetic field effects on human subjects related to magnetic resonance imaging systems. *Progress in Biophysics and Molecular Biology* 87: 255-265.
9. FDA (2003) *Criteria for significant risk investigations of magnetic resonance diagnostic devices*. Available at: www.fda.gov/cdrh/ode/guidance/793.pdf.
10. Food and Drug Administration (FDA) (1997) *Guidance for Magnetic Resonance Diagnostic Devices-C-Criteria for Significant Risk Investigations*. Rockville, MD: US Food and Drug Administration.
11. Gowland PA (2005) Present and future magnetic resonance sources of exposure to static fields. *Progress in Biophysics and Molecular Biology* 87: 175-183.
12. IEC (2001) *Particular requirements for the safety of magnetic resonance equipment for medical diagnosis*. Geneva: IEC; 60601-2-33.
13. Irpa/INIRC Guidelines (1991) Protection of the patient undergoing a magnetic resonance examination. *Health Physics* 61: 923-928.
14. Liu F., Zhao HW, and Crozier S. (2003) Calculation of electric fields induced by body and head motion in high-field MRI. *Journal of Magnetic Resonance* 161: 99-107.
15. McJury M. and Shellock FG (2000) Auditory noise associated with MR procedures: a review . *Journal of Magnetic Resonance Imaging* 12: 37-45.
16. Mansfield P., Haywood B., and Coxon R. (2001) Active acoustic control in gradient coils for MRI . *Magnetic Resonance in Medicine* 46: 807-818.
17. Marzola P., Osculati F., and Sbarbati A. (2003) High field MRI in preclinical research. *European Journal of Radiology* 48: 165-170.
18. Nyenhuis JA, Bourland JD, Kildishev AV, and Schaefer DJ (2001) *Health effects and safety of intense gradient fields* . In: Shellock FG (ed.) *Magnetic Resonance Procedures: Health Effects and Safety*. New York: CRC Press, 31-53.
19. Scarabino T., Nemore F., Giannatempo GM, Bertolino A., Di Salle F., and Salvolini U. (2003) 3.0 T magnetic resonance in neuroradiology. *European Journal of Radiology* 48: 154-164.
20. Schenck JF (2000) Safety of strong, static magnetic fields. *Journal of Magnetic Resonance Imaging* 12: 2-19.
21. Schenck JF (2005) Physical interactions of static magnetic fields with living tissues. *Progress in Biophysics and Molecular Biology* 87: 185-204.
22. Shellock FG (2001) *Magnetic Resonance Procedures: Health Effects and Safety* . New York: CRC Press, 75-96.
23. Shellock FG, Ziarati M., Aitkinson D., and Chen DY (1998) Determination of acoustic noise during MRI using echo planar and three dimensional fast spin echo imaging techniques. *Journal of Magnetic Resonance Imaging* 8: 1154-1157.
24. SSK (2003) Recommendations on the safe application of magnetic resonance in medical diagnostic. Recommendation of the German Commission on Radiological Protection (SSK), approved in the 180 Session of the SSK on 19/20 September 2002. Munich : Urban and Fischer; *Reports of the SSK*, Vol. 36.
25. Van Deventer TE, Saunders R., and Repacholi MH (2005) WHO health risk assessment process for static fields . *Progress in Biophysics and Molecular Biology* 87: 355-363.