



ORIGINAL RESEARCH PAPER

Technology

PRINCIPLES OF MAGNETIC RESONANCE TECHNOLOGY IN MEDICAL IMAGING OF NON IONIZATION IMAGES

KEY WORDS: Education, X-ray tube, X-rays, Non Ionization Radiation , X-ray Radiologists & Radioprotection Protection, Medical Instruments Technologists, X-ray Departments Nurses, X-ray Departments Doctors, Medical Imaging

Ioannis Vlachos*

TEI of Athens, School. School of Technological Appliace, Department of Medical Instruments. bDepartment of Medical Physics, School of Medicine, University of Patras, Rion, Patras, Greece. *Corresponding Author

ABSTRACT

The X-ray tube is one of the most important components in any X-ray system. In the beginning, physicists and physicians used gas ion tubes. The so-called Coolidge tube applied a high vacuum and is still used today. Medical examinations have required continuously improved designs of X-ray tubes (smaller focal spots at a higher output). The principle of the Goetze line focus is still applied in any diagnostic X-ray tube. Different anode materials and the rotating anode contributed to an increased output and reduced exposure time. Bearings needed special attention. Spiral groove bearings are the most advanced design today. The heat storage capacity of the anode and the tube housing assembly influences examination time and patient throughput. Cardiac imaging required less motion blurring in cine film images and increasing radiation exposure in interventional procedures called for measures to reduce dose. Protection against radiation and electric shock has always been a concern of design engineers. Focal spot sizes dedicated to specific applications and heat management within the total tube housing assembly will be future issues. Even with the event of ultrasound and MR technology, X-ray procedures will still be applied for diagnostic and interventional purposes.

1. Introduction

Nuclear magnetic resonance (NMR) was first described and measured in molecular beams by Isidor Rabi in 1938, extending the Stern – Gerlach experiment, and in 1944, Rabi was awarded the . In 1946, Felix Bloch and Edward Mills Purcell extended the technique to be used in liquids and solids, for which they shared the Nobel Prize in Physics in 1952. Yevgeny Zavoisky nuclear magnetic resonance in 1941, well before Felix Bloch and Edward Parcel, but dismissed the results as non-reproducible. Parcel worked on radar development during World War II at the Massachusetts Institute of Technology. His work during this project in the generation and detection of radio frequency (RF) power and in the absorption of such radio frequency power from matter led to the discovery of Nuclear Magnetic Resonance (NMR) by Rabi. Rabi, Bloch and Parcel observed that magnetic nuclei, such as 1H (hydrogen) and 31P (phosphorus), could absorb radio frequency (RF) energy when placed in a magnetic field and when RF was the specific frequency for identifying nuclei. When this absorption occurs, the nucleus is described as being in tune. Different atomic nuclei in a molecule are tuned to different (radio) frequencies for the same magnetic field strength. Observing such magnetic resonance frequencies of nuclei present in a molecule allows any trained user to discover basic chemical and structural information about the molecule. The development of NMR as a technique in analytical chemistry and biochemistry is done in parallel with the development of electromagnetic technology and advanced electronics [1].

- The development of NMR as a technique in analytical chemistry and biochemistry is done in parallel with the development of electromagnetic technology and advanced electronics. Nuclear Magnetic Resonance (NMR) is a natural phenomenon in which nuclei in a magnetic field absorb and re-emit electromagnetic radiation (RF). This energy has a specific tuning frequency that depends on the strength of the magnetic field and the magnetic properties of the isotope of the atoms in practical applications, the frequency is similar to the VHF and ultra high frequency (UHF) frequencies (60-1000 MHz). NMR allows the observation of specific quantum magnetic properties of the atomic nucleus. Many scientific techniques take advantage of NMR phenomena to study molecular physics, crystals and non-crystalline materials through NMR spectroscopy. NMR is also used systematically in advanced medical imaging techniques, such as Magnetic Resonance Imaging (MRI). All isotopes containing an odd number of protons and / or neutrons

have an internal magnetic moment and torque, in other words a non-zero spin or self-rotation or idiosyncrasy or idiosyncrasy, while all nuclides (or nuclides) with even numbers of both have a total spin of zero. The most commonly studied nucleides are 1H and 13C, although the nuclei from isotopes of many other elements such as 2H, 6Li, 10B, 11B, 14N, 15N, 17O, 19F, 23Na, 29Si, 31P, 35Cl, 113Cd, 129Xe, 195Pt have been studied by high field NMR spectroscopy, as well. A key feature of NMR is that the tuning frequency of a particular substance is directly proportional to the intensity of the applied magnetic field. This feature is used in imaging techniques if a sample is placed in a heterogeneous magnetic field, then the resonant frequencies of the sample nuclei depend on where they are in the field. Because the resolution of the imaging technique depends on the magnitude of the magnetic field gradient, many attempts are made to develop increased field strength, often using superconductors. The efficiency of NMR can also be improved using hyperpolarization and / or using two-dimensional, three-dimensional or higher-dimensional multi-frequency techniques. The principle of NMR usually involves two successive steps:

- The alignment (polarization) of the nuclear magnetic spins in an applied, fixed magnetic field H_0 .
- Disrupting this alignment of nuclear spins using an electromagnetic pulse, usually radio frequency (RF). The required disturbance frequency depends on the static magnetic field (H_0) and the observation cores [1].

1.1. Nuclear spin and magnets

All nucleons, ie neutrons and protons, that make up any atomic nucleus, have the inherent quantum property of spin. The total spin of the nucleus is determined by the spin quantum number S. If the numbers of both protons and neutrons in a given nucleid are odd then $S = 0$, ie there is no total spin, just as electrons pair in atomic orbitals, so do even numbers of protons or even numbers of neutrons mate giving a total spin of zero. However, a proton and a neutron will have lower energy when their spins are parallel, not opposite. The parallel alignment of the spin does not violate the Pauli Exclusion Principle. spin alignment does not violate the Pauli Exclusion Principle. The reduction in energy for parallel spins has to do with the quark structure of these two nucleons. Therefore, the basic spin state for deuterium (the deuterium nucleus, or hydrogen isotope 2H) — which has only one proton and one neutron — corresponds to a spin value of 1, not zero.

The simple, isolated deuteron therefore exhibits a characteristic NMR absorption spectrum of a quad-core nucleus with spin 1, which in the "solid" state at very low temperatures is a typical Pake pair (not a simple peak as for the simple, isolated 1H, or any other isolated fermion or bipolar core with spin 1/2). On the other hand, due to the Pauli Exclusion Principle, the isotope of the hydrogen tritium must have a pair of neutrons with opposite spins (with total spin zero), plus a proton with spin 1/2. So the character of the tritium nucleus is again a magnetic dipole, not a quadrupole — like its non-radioactive cousin deuterium — and the total spin value of the tritium nucleus is again 1/2, just like for the simplest, most abundant hydrogen isotope. 1H nucleus (the proton). The (radio) absorption frequency of NMR for tritium is, however, slightly higher than that of 1H, because the tritium nucleus has a slightly higher gyromagnetic ratio than 1H. In many other cases of non-radioactive nuclei, the total spin is also non-zero. A non-zero spin is therefore correlated with non-zero magnetic moment (i) through the relation $i = \bar{a}S$, where \bar{a} is the gyromagnetic ratio. It is this magnetic moment that allows the observation of NMR absorption spectra caused by transitions between nuclear spin stations. Most nucleids (with a few rare exceptions) that have both proton and neutron numbers even have zero nuclear magnetic moments as well as zero magnetic bipolar and quadrupole torques. Therefore, such nucleides do not show NMR absorption spectra. Thus, 18O is an example of a nucleide that does not have NMR absorption, while 13C, 31P, 35Cl and 37Cl are nucleides that show NMR absorption spectra. The last two nuclei are quadrupole nuclei, while the previous two nuclei (13C and 31P) are bipolar. Electron spin resonance (ESR) is a related technique in which transitions between electronic spin stations are detected instead of nuclear transitions. The basic principles are similar, but organology, data analysis, and detailed theory differ significantly. In addition, there is a much smaller number of molecules and materials with unpaired electron idiosyncrasies that exhibit ESR absorption (or electron paramagnetic resonance (EPR)) compared to materials having NMR absorption spectra. ESR is much more sensitive than NMR [2] [4].

1.2. Spin torque values

The torque associated with nuclear spin is quantized. This means that the magnitude of the torque is also quantized (ie S can take limited values) and also the orientation of the relative torque is quantized. The relative quantum number is known as the magnetic quantum number, m and can take values from +S to -S, in whole steps. Therefore, for any given kernel, there is a set of 2S + 1 torque states. The component z of the torque vector (S) is therefore $S_z = m\hbar$, where \hbar is the reduced Planck constant. The z component of magnetic moment is simply:

$$i_z = \bar{a}S_z = \bar{a}m\hbar$$

1.2.1. Spin Behavior in a Magnetic Field

Consider nuclei having a spin of one second (1/2), such as 1H, 13C, or 19F. The nucleus has two possible spin states: $m = 1/2$ or $m = -1/2$ (also referred to as spin-up and spin-down, or sometimes as a and b spin states, respectively). These states are degenerate, that is, they have the same energy. Thus, the number of atoms in these two states will be approximately equal to the thermal equilibrium. If the nucleus is placed in a magnetic field, the interaction between the nuclear magnetic moment (i) and the external magnetic field (B₀) means that the two states no longer have the same energy. The energy of the magnetic moment i when it is in a magnetic field B₀ is given by: Usually the z axis is chosen to be along B₀ and the above expression is:

$$E = -\gamma \bar{a} m \hbar B_0$$

As a result, different nuclear spin states have different energies in a non-zero magnetic field. In less scientific language, we can speak of two spin states of a 1/2 spin aligned with either the magnetic field or vice versa. If \bar{a} is

positive (which is true for most isotopes) then $m = 1/2$ is the lowest energy state.

1.2.2. Nuclear magnetic resonance

frequency (e.g., is equal to the Larmor precession rate) to match the energy difference between the nuclear spin levels in a constant magnetic field of appropriate strength. The energy of an absorbed photon is then $E = \hbar \omega$, where ω is the tuning radio frequency that must match (that is, it must be equal to the Larmor precession frequency ω_L of the nuclear magnetism in the constant magnetic field B₀). Thus, magnetic resonance absorption will occur only when $DE = \hbar \omega$. Such magnetic resonance frequencies usually correspond to the radio frequency (or RF) range of the electromagnetic spectrum for magnetic fields up to roughly 20 T. It is this magnetic resonant absorption detected in the NMR.

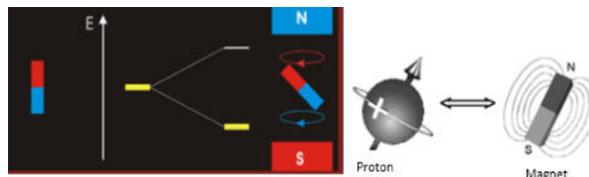


Fig. 1

The nuclei behave as if they had their own magnetic moments (spin magnetic moments). By itself, there is no energy difference for any particular orientation (only one state of energy, on the left), but in the external magnetic field there is a state of high energy and a state of low energy depending on the relative orientations of the magnet to the external field. and the orientation of the magnetic moment can shift relative to it. The external field can be provided by a large magnet and also by other neighboring nuclei [2] [4].

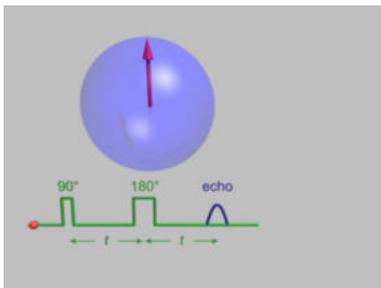
1.2.3. Nuclear shielding

It can be seen from the above that all nuclei of the same nucleid (and therefore of the same \bar{a}) would be tuned to the same frequency. But this is not the case. The most important NMR frequency disturbance for NMR applications is the "shielding" effect of surrounding electron layers. Electrons, similar to the nucleus, are also charged and rotated by a spin to produce a magnetic field opposite to the magnetic field generated by the nucleus. In general, this electronic shield reduces the magnetic field in the nucleus (which is what determines the NMR frequency). As a result the energy gap is reduced and the frequency required to achieve tuning is also reduced. This shift in NMR frequency due to the electronic coupling of the molecular orbital to the external magnetic field is called chemical shift and explains why NMR can detect the chemical structure of molecules, which depends on the density distribution of electrons in the respective molecular orbitals. If a nucleus in a particular chemical group is shielded to a greater extent by a higher electron density than the surrounding molecular orbitals, then the NMR frequency will shift "to higher field values (upfield)" (i.e., a lower chemical displacement), while if it is less shielded from such an surrounding electrical density, then the NMR frequency will shift "to the lower field values" (i.e., a larger chemical shift). Unless the local symmetry of such molecular orbitals is very high (leading to "isotropic" displacement), the shielding effect will depend on the orientation of the molecule with respect to the external field (B₀). In solid-state NMR spectroscopy, magic angle spinning is required to balance this orientation dependence to obtain values close to the mean chemical displacements. This is unnecessary in conventional molecular research with NMR, because rapid "molecular tumbling" balances the (chemical shift anisotropy) (CSA). In this case, the term "average chemical shift" (ACS) is used [2] [4] [5].

1.3. Relaxation Times

The process called population relaxation refers to nuclei that

return to the thermodynamic state of the magnet. This process is also called spin-lattice relaxation time (T1), or "longitudinal magnetic relaxation", where T1 refers to the average time for an individual nucleus to return to its thermal equilibrium state for the spins. When the spin nuclear population is restored, it can be re-examined, as it is in its initial state of equilibrium. Larmor transition nuclei can also break alignment with each other (returning the pure magnetism vector to a non-transition field) and stop signal generation. This is called spin-spin relaxation time (T2) or transverse relaxation. Due to the difference in the active recovery mechanisms involved (for example, intermolecular-intramolecular magnetic dipole-dipole interactions, T1 is usually (except in rare cases) greater than T2 (i.e., slower spin-mesh recovery, for example due to more In practice, the value of T2, which is the actual observed breakdown time of the observed NMR signal, is the Free Induction Decay (at 1/e of the initial amplitude immediately after the pulse). also depends on the static magnetic field heterogeneity, which is quite significant. (There is also a smaller but significant contribution to the observed FID (Free Induction Decay). In the corresponding FT-NMR spectrum — meaning the Fourier transform of free induction decay — the time T2 is inversely related to the amplitude of the NMR signal in frequency units. Thus, a nucleus with a long T2 return time leads to a very acute NMR peak in the FT-NMR spectrum for a very homogeneous static magnetic field, where nuclei with lower T2 values lead to wide FT-NMR peaks even when the magnet well regulated. Both T1 and T2 depend on the degree of molecular motion as well as the gyromagnetic ratios and their resonances and strong interactions on adjacent non-resonant nuclei. A spin echo splitting experiment can be used to calculate the phase synchronization time, as shown in the video below. The magnitude of the echo is recorded for different distances of the two pulses. This reveals the decoherence which is not refocused by the pulse. In simple cases, an exponential decay is measurable and is described by time T2. Visualization (of the following link) of the relaxation times T1 and T2.
https://upload.wikimedia.org/wikipedia/commons/transcoded/1/11/Proton_spin_MRI.webm/Proton_spin_MRI.webm.480p.webm



• **Recovery time T1**

Stimulated protons interacting with the environment yield the extra energy in it in the form of heat and return to state of equilibrium. The restoration of magnetization at equilibrium value follows the relationship:

$$M_z = M_0 \left(1 - e^{-\frac{t}{T_1}} \right)$$

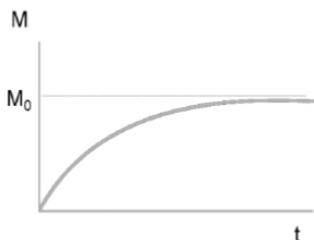


Fig. 2

where Mz is the longitudinal magnetization at time t, M0 is the longitudinal magnetization at equilibrium and T1 the characteristic time spin - lattice relaxation time. The above relation presupposes that the magnetization at time t = 0 is zero (firing angle 90o). Its graph is given in the above shape. The typical recovery time T1 depends on the intensity where Mz is the longitudinal magnetization at time t, M0 is the longitudinal magnetization at equilibrium and T1 the characteristic time spin - lattice relaxation time. The above relation presupposes that the magnetization at time t = 0 is zero (firing angle 90o). Its graphic is given in the above shape. The typical recovery time T1 depends on the intensity of the external magnetic field and the random molecular motions in the proton environment. These movements create temporal and local fluctuations of the magnetic field. When these fluctuations occur close to the resonant frequency (Larmor) then transitions of excited protons to the equilibrium state are more easily induced and the T1 time is reduced. Conversely, when the local fluctuations of the magnetic field are slower or faster than the resonant frequency, then the recovery time T1 increases. For example, small molecules such as water move very fast and do not allow the excited protons to deliver the energy of the radio pulses to the environment, resulting in a large T1. On the contrary, the random movements of large molecules or water molecules bound by large molecules are done with frequencies closer to the resonant frequency and thus the energy transfer to the environment is more efficient and the recovery time T1 is shorter (Fig. 9). Recovery time depends on temperature and magnetic field. An increase in temperature causes faster movements and usually facilitates the transition to the equilibrium state by reducing the T1 time. On the contrary, an increase in the magnetic field causes through the above relation an increase in the Larmor frequency to frequency bands where there is usually not enough contribution from the ambient noise resulting in a reduction of the probability of transition to equilibrium and consequently an increase of T1 [3] [7].

• **Recovery time T2**

The second mechanism of signal loss is related to the synchronization of the transition of excited protons as they rotate in the transverse plane. Immediately after the spin is deflected from the radio plane they all rotate together in the transverse plane with the same phase (= same angle) and the induced signal is strong. Over time, however, protons interact with each other and thus are created local, random fluctuations of the magnetic field resulting in phase differences (= some are delayed and others are ahead) and the Mxy transverse magnetization decreases according to the relation:

$$M_{xy} = M_{xy0} e^{-\frac{t}{T_2}}$$

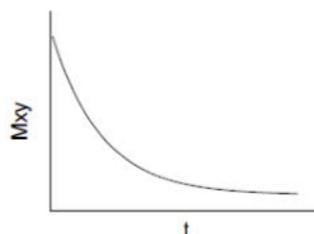


Fig 3.

where Mxy is the transverse magnetization at time t, Mxy0 is the transverse magnetization immediately after the application of the radio pulse and T2 is the characteristic spin - spin relaxation time. It is obvious that in materials with small flexible molecules they spins interact weakly (eg liquids) the time T2 will be long since the local fluctuations of the magnetic field will be very short and consequently the phase losses will be small. In contrast, for large, cumbersome molecules that interact strongly and for a long time (eg solids)

or for water molecules that are bound to them, the T2 time will be short (figure down) [2].

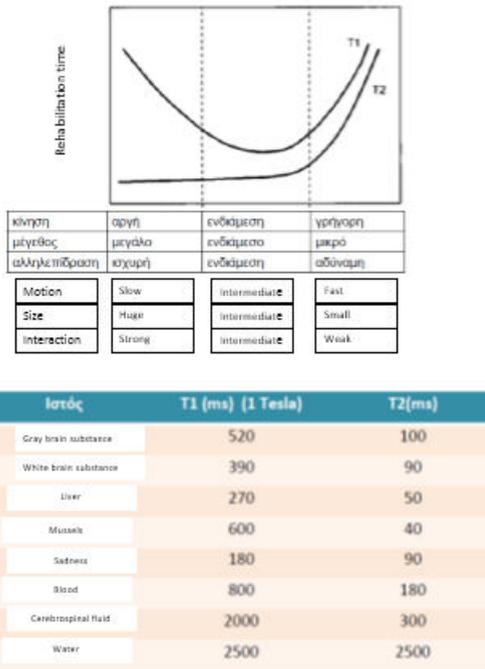


Fig 4.

2.4. Applications Medicine

The most well-known application of nuclear magnetic resonance (NMR) to the general public is Magnetic Resonance Imaging for medical diagnosis and magnetic resonance microscopy in research applications. It is also widely used in chemical studies, especially in NMR spectroscopy such as proton, carbon-13, deuterium and phosphorus-31 NMR. Biochemical information can also be obtained from living tissues (e.g., human brain tumors) by a technique known as in vivo magnetic resonance spectroscopy or NMR chemical shift microscopy. These studies are possible because the nuclei are surrounded by orbital electrons, which are charged particles that create small, local magnetic fields that are added to or removed from the external magnetic field and thus partially shield the nuclei. The degree of shielding depends on the exact local environment. For example, a hydrogen attached to an oxygen will be shielded differently from a hydrogen attached to a carbon atom. In addition, two hydrogen nuclei can interact through a process known as spin-spin coupling, if they are in the same molecule, dividing the spectrum lines in a recognizable manner. NMR is one of the two main spectroscopic techniques used in metabolomics and is used to create metabolic imprints from biological fluids to obtain information about disease status or toxicity [3] [7].

2. Materials & Methods

Special mention must first be made of the mathematician Joseph Fourier who discovered the transformations of the same name, without which it would be impossible today to reconstruct the spectra, and of Nikola Tesla for his inventions of electromagnetism which gave great impetus to the further development of technology. Initially in 1924 Pauli after a series of studies proposed the theoretical existence of an inherent nuclear rotation. In 1925 Uhlenbeck and Goudsmit introduced the concept of the rotating electron into physics. Two years later, Pauli and Charles Galton Darwin developed a theoretical framework for the concept of electron rotation based on the laws of quantum mechanics developed by Erwin Schrödinger and Werner Heisenberg [3].

The first studies of phosphorus spectroscopy for the analysis

of erythrocyte samples were performed in the early 1970s (Moon 1973). In 1974, Houtt studied the composition of mouse muscle tissue using phosphorus spectroscopy. It then becomes apparent that spectroscopy offers a non-invasive in vivo analysis of tissue composition and metabolism. Magnetic Resonance Imaging (MRI) or, as it is better known in Greece, Magnetic Resonance Imaging is a radiological method of imaging the interior of an organism. It is considered a huge medical breakthrough [3].

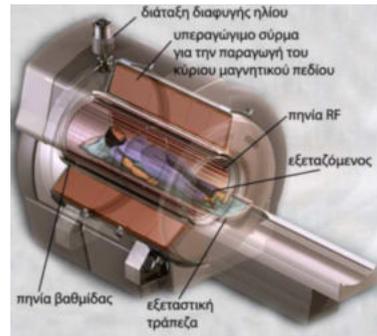


Fig 5.

Medical MRI System.

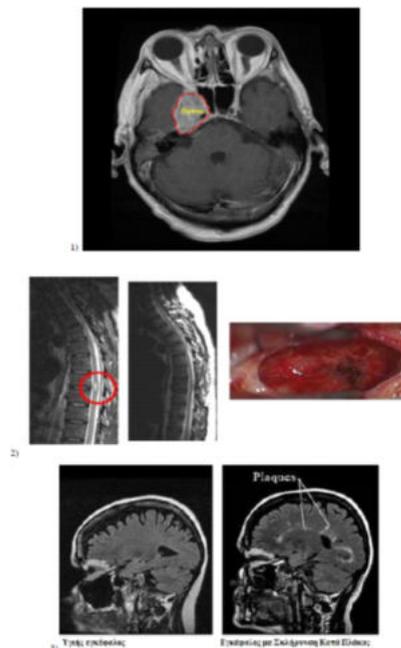


Fig 6.

MRI imaging.

- 1) MRI with cancer of the nasopharynx.
- 2) Preoperative and postoperative spine with tumor.
- 3) Healthy brain and Multiple Sclerosis brain.

2.1. Technical shooting

The subject is placed in a strong magnetic field (at least 1.5 Tesla-15,000 times stronger than the earth's magnetic field). Under these conditions the body's hydrogen nuclei (found in almost all compounds - water, fat and other organic compounds) orient themselves parallel to the magnetic field lines and perform a transient motion around the axis of the magnetic lines with a certain frequency of rotation, (Larmor frequency). This condition is common in most common people. The quantity ω is equal to the ratio of the magnetic moment due to spin to the spin due to spin. The ratio ω is called the gyromagnetic ratio of the spin. It is obvious that for a given external field each type of atomic nucleus performs a transient motion with a certain frequency (eigenfrequency), which is different for each individual. This transient motion is a means of exploring the different types of nuclei contained in a body, whether it is a sample of a biological or chemical substance or a history of a subject.

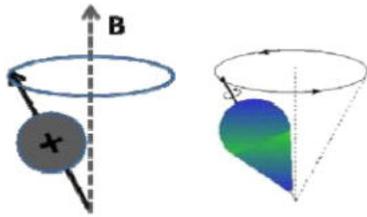


Fig 7.
Transient motion of a proton.

During the test, the MRI radiofrequency emits RF (radio waves) at a frequency equal to that of the nuclei (Larmor frequency). The nuclei absorb the electromagnetic energy and the situation changes their rotation. After excitation with RF pulses, while the trajectories return to their original state, they emit a weak radio frequency signal at the Larmor frequency (with small deviations). The weakly transmitted RF signal we receive is the magnetic resonance signal. This signal decreases over time and is called the Free Induction Decay signal. Then with the application of Fourier transform in FID (signal in the time domain) we receive the signal in its final form, ie in the frequency domain. During MRI examinations, the spatial determination of the received signals is done by superimposing gradient magnetic fields which locally change the strength of the main field resulting in a small change in the resonant frequency of the hydrogen nuclei. In this way, RF emission of pulses with a certain frequency range stimulates specific areas (and their position can be determined based on differences in the frequency and rotation rate of protons) [6].

2.2. MRI structure

The main component of the system is the main magnet that produces the external static field B_0 . There are three types of magnets used in modern imaging systems:

1. Permanent magnets, 2. Superconductive magnets, and 3. Resistive magnets. Permanent magnets are made of a permanently magnetized material. Superconductors and resistance magnets consist of coils or tubes that leak electricity. They operate on the principle of generating a magnetic field in the environment of a power line. In the case of superconducting magnets the construction material is selected to present the phenomenon of superconductivity (superconductivity/superconductivity). That is, the phenomenon in which the electrical resistance is zeroed at low temperatures (lower than a certain value which is different for each material). In addition to the basic magnet, an imaging system must have four other types of coils:

1. Gradient coils, for the production of the field step and the spatial determination of the displayed area,

2. Smoothing coils (shim coils), for smoothing of static magnetic field inhomogeneities,

3. Radio frequency coils (RF coils), for generating magnetic pulses and detection of FID signals (Free Induction Decay), and

4. Surface coils, for excitation of the selected area of the body. Finally, the imaging system includes a powerful computer for the reconstruction and processing of received signals. The whole system of the magnet, with the various coils, is located in the basic body (or scaffold-gantry) of the machine. The body is usually approximately rectangular in shape with a tunnel opening in the middle of the façade. The patient is inserted into this opening. The aperture is significantly larger in the so-called open magnet systems. In such systems the basic body of the machine may be in the form of two cylindrical rings. There is enough space between the rings to facilitate surgery (in operating rooms). In other systems the machine body has two cylindrical bodies (poles), one of which is above the patient and the other below. Therefore there is sufficient space between the poles for surgeries, for examinations of children and for the facilitation of claustrophobic patients. The main body of the machine is placed in a properly arranged space called a scan room [6] [7].

2.3. Advantages - Disadvantages

With the exclusive use of MRI it is possible to obtain information about the biochemical state of tissues in the form of images and spectra. MRI offers the possibility of early detection of various biochemical changes that occur before the formation of malignancy. Also in relation to other imaging methods, which are based on the detection of specific tracers with specialized action, they offer greater sensitivity, better resolution and greater flexibility in application. MRI offers a variety of tools to find and monitor the course of various lesions as well as the possibility of multiple repetitions since patients are not exposed to ionizing radiation or other chemicals. Its application also bridges the gap between anatomical imaging and molecular imaging as it offers the possibility of spatial imaging of the functional state of tissues. With the help of magnetic resonance imaging it is possible to stage and characterize, to assess the course of the disease and to observe the response of the tissues to the treatment. The applicability to almost all anatomical areas and the rapid development of relevant technology promise faster, better and even more timely diagnosis compared to other more complex and expensive diagnostic methods. In summary, the main advantages are: a. The exploitation of multiple physical parameters for obtaining spectra and metabolic maps of high diagnostic value at all three spatial levels. b. Avoiding charging the subject with ionizing radiation (X, α , β radiation - possibility of recurrence without significant effects) [5] [6].

3. Results & Discussion

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development of relevant technology promise faster, better and even more timely diagnosis compared to other more complex and expensive diagnostic methods. In summary, the main advantages are: a. The exploitation of multiple physical parameters for obtaining spectra and metabolic maps of high diagnostic value at all three spatial levels. b. Avoiding charging the subject with ionizing radiation (X, γ , β radiation - possibility of recurrence without significant effects). c. The determination of the biochemical composition of the organism by painless procedures, with non-invasive character.

Magnetic resonance imaging, although it has brought a new revolution in radiodiagnostics, also has some disadvantages:

a. The abundance of applications and the requirement of complex knowledge of physical parameters, computers, mathematics, physiology and anatomy for the proper use of this tool makes its application relatively difficult.

c. The interpretation and processing of images and quantitative data as well as the difficulty of recognizing false indications.

d. The devices used in medicine have a high cost (about one million dollars per Tesla for one unit, as well as a few thousand Euros (€) for their maintenance) [5] [6] [7].

3.1. Magnetic resonance imaging

These are substances that are used, as in other imaging methods, to enhance the contrast between two tissues. The substances used in magnetic resonance are completely different from those of X-rays. A key difference is the mechanism by which the amplification of the contrast is achieved. X-rays use a large number of atomic materials that absorb radiation. In magnetic resonance the amplification of the contrast is based on the change of the magnetic restoration times. The substances used are mainly paramagnetic ions, paramagnetic complexes and molecular oxygen. These are molecules or ions that have an unpaired (single) electron. This electron has a high magnetic moment. When a paramagnetic substance is found in a magnetic field (B0) the magnetic moments are oriented parallel to the dynamic lines of the field. The result is a change in the intensity of the local field with corresponding changes in the magnetic recovery times of neighboring tissues (which are of diagnostic interest). What is interesting, in terms of enhancing the contrast, is the reduction of the magnetic recovery time. This reduction results in the amplification of the signal coming from the examined tissue. The reduction of the magnetic recovery time is proportional to the concentration of the paramagnetic substance and the square of the magnetic moment. The contrast agents can be administered by intravascular injection, orally or by inhalation. Gadolinium (Gd3+), Chromium (Cr3+) and Manganese (Mn2+) ions bound to chemical complexes such as EDTA and DTPA, as well as free fixed radicals of nitric oxide N-free radical N the piperidine and pyrrolidine derivatives. Soluble metal ions such as (ferric ammonium citrate), soluble metal ion symbols such as Cr-EDTA and insoluble substances (gadolinium oxalate) have been proposed as orally administered substances. Finally, for inhalation administration, molecular oxygen has been proposed which has two unpaired electrons (with parallel spins) and is therefore paramagnetic. In addition to the contrast agents that affect T1 and T2 temporals, substances that affect proton density have been proposed but without significant applications so far [6].

4. Conclusions

An important advantage of magnetic resonance imaging is that the subjects and staff are not exposed to ionizing radiation. Regarding the effect of static fields on biological organisms there are a number of data from other workplaces such as e.g. Nuclear Physics laboratories using particle accelerators. There are also results from animal experiments

(mainly mice). In general, with few exceptions, both short-term and long-term harmful biological effects have not been observed to date. E.g. mutogenic effects, electrical conduction of nerves (nerve conduction E.C.G. characteristics). The development of small electrical potentials in large-diameter vessels moving vertically in the field does not appear to have an effect on heart function. Objects made of ferromagnetic material tend to rotate so as to align with the dynamic lines of the field. In some cases (aneurysm clips, heart valves) this is destructive. Also, such objects distort the magnetic field and thus degrade the quality of the diagnostic image. Depending on the legislation of each country, the maximum static magnetic field is set at 2 or 2.5 T (USA, UK). One basis for determining the 2.5 Tesla limit is the fact that, at such field values, a voltage of approximately 40 mVolt (2.5 Tesla x 16 mVolt / Tesla) develops in the walls of the aorta. A value of 40 mVolt is a limit beyond which depolarization of cardiac muscle fibers occurs. Finally, there are problems with the operation of the pacemakers. Therefore, patients with a pacemaker should be excluded from magnetic resonance imaging. They should also not approach areas with fields stronger than 3 or 5 Gauss. One problem that must be foreseen by the regulations is the possibility of launching small metal objects due to the development of strong magnetic forces. Therefore the presence of metal object detectors (usually in the form of an arch) is necessary in any magnetic resonance unit. Particular attention should be paid to the information and familiarization of the personnel of each category with the properties of the magnetic field and all kinds of phenomena due to its existence e.g. Instruments and tools used in the maintenance of the system may not function properly, may not be used or may not be allowed in the field (due to danger). People who may enter the area where the machine is located outside of normal business hours (eg cleaners, security guards, firefighters) may be at risk if they are not notified. Strict control should also be performed on various objects for which the presence of ferromagnetic material is suspected. In general, the space must be carefully guarded or locked during off-hours, especially when it comes to strong superconducting magnets. Problems may occur in the subjects during the abrupt interruption of the magnetic field (quenching), e.g. development of inductive currents in the patient that may cause a heart attack [6].

5. References

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