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## Magnetic resonance imaging as a diagnostic method

Patrycja Ręba

Faculty of Medicine and Health Sciences,  
Jan Kochanowski University in Kielce

MSc. Patrycja Ręba

### Abstract

#### Admission

In human medicine, magnetic resonance imaging (MRI) is one of the leading and most popular diagnostic methods. In veterinary medicine, initially, MRI was treated mainly as a research tool, but with the development of veterinary specializations, an increase in the number of specialists, reference clinics, but also an increase in awareness and expectations of animal owners, MRI began to play a key role in the clinical practice of small animals - dogs and cats , exotic animals and horses.

#### Aim

The aim of the study is the analysis of magnetic resonance as a diagnostic method.

#### Material and method

Review of the available literature on the subject.

#### Results

Magnetic resonance imaging is based on the phenomenon of nuclear magnetic resonance, characteristic of the nuclei of elements with an odd number of protons or neutrons, and therefore having a momentum (spin) and a magnetic moment. The most commonly used element is the hydrogen atom, thanks to its richness in living organisms. The general scheme of how MRI works is a five-step process involving the following phenomena:

Placing the patient in a constant homogeneous electromagnetic field

Radio frequency (RF) signal emission

Interruption in RF signal emission

RF feedback by the body

Processing of the emitted signal and image reconstruction.

Currently, the most popular areas of research are the central nervous system (brain and spine) and the musculoskeletal system. The test allows you to diagnose intracranial diseases such as: birth defects, inflammatory changes in the brain tissue, demyelinating diseases or cancer.

#### Conclusions

The versatility of magnetic resonance imaging, both in terms of species diversity (small animals, horses, exotic animals) and imaging areas (central and peripheral nervous system, bones with their joints, muscle tissue) has made MRI a very important method diagnostic used in clinical veterinary medicine. The other advantages of magnetic resonance imaging

include imaging in three planes, enabling subsequent three-dimensional reconstruction, no harmful X-rays and the possibility of using contrast agents.

**Key words: Magnetic resonance imaging; diagnostic method**

Magnetic resonance imaging (MRI) is a non-invasive method of imaging the human body. It allows you to obtain any images of body sections without the use of ionizing radiation. The theory of RM image formation is complicated. To simplify it, the spin phenomenon is used, that is, the "swaying" movement that is performed by the nucleus of the atom. In the case of magnetic resonance imaging, it concerns hydrogen, which is, among others, a component of the water molecule ubiquitous in the body (H<sub>2</sub>O), hence, in MRI, for example, the degree of tissue hydration can be assessed. In fact, magnetic resonance imaging is much more complicated and the obtained data provide much more information [1,2,9].

The phenomenon of magnetic resonance was discovered in 1946 independently by Felix Bloch and Edward Purcell. Felix Bloch (1895–1983) emigrated from Switzerland to the United States in 1933, where, after the end of World War II, he conducted research on nuclear magnetic resonance (NMR) and gave the so-called Bloch equations. Edward Mills Purcell (1912–1997) worked on nuclear magnetic resonance in 1945–1946 independently of Bloch. In 1952, both scientists received the Nobel Prize in Physics for the development of new methods in the field of precise nuclear magnetic methods and for the discoveries made with their application [2,11].

Magnetic resonance imaging was initially used for molecular structure studies (MR spectroscopy) and diffusion weighted imaging (DWI) studies. In 1973, Paul Lauterbur obtained the first MR image using linear gradients. In the 1970s, MR was used for scientific purposes, and from the 1980s also in clinical practice. The rapid development of the MR technique took place in the 1990s [3, 12].

Magnetic resonance imaging is considered safe. The use of a magnetic field, typically 0.5 to 3.0 Tesla (up to 20,000 times the Earth's) does not cause significant interaction with the body. So far, none of the numerous scientific studies have shown a harmful effect of MRI on the human body. Pregnancy is not a contraindication to the examination, however, MRI in the first trimester is not recommended. Menstruation is not a contraindication to the study [2,6].

MRI imaging can be performed in various sequences. Seemingly slight changes in the setting of basic imaging parameters may lead to obtaining slightly different data, giving different diagnostic possibilities. Due to the basic parameters, imaging methods are divided into:

- T1 weighted images (see illustration) best representing visually the anatomical structure of the brain, where white matter is shown in bright colors, and gray matter in the dark, cerebro-spinal fluid, abscess and tumor dark, and liver parenchyma light
- T2-weighted images in which white matter is shown in darker colors and gray matter in lighter colors, cerebrospinal fluid, tumor, abscess, hemangioma of the liver and spleen in light, and the liver and pancreas in dark
- FLAIR (fluid-attenuated inversion recovery), a certain modification of the T2-weighted sequence, where areas with little water are shown in darker colors, and areas with a lot of water in lighter colors. The imaging in this sequence finds good application in detection of demyelinating diseases.
- diffusion imaging, measuring the diffusion of water molecules in a tissue. The following techniques are distinguished here: diffusion-weighted imaging (DTI), which can be adapted to imaging changes in white matter connections, and diffusion-weighted imaging (DWI), which shows high imaging efficiency in strokes [4,10].

The technique of RM is complemented in vivo magnetic resonance spectroscopy, allowing to obtain magnetic resonance spectra of the examined areas of the organism [1,2].

The patient's safety may be at risk if there are metal objects in his body, such as foreign bodies - metal shards, vascular clamps placed during previous operations, and especially various types of stimulators, the work of which, if turned on, may be seriously disturbed.

Therefore, the presence of the above-mentioned metal elements in the human body is a contraindication to the examination. The strong magnetic field generated during the test is capable of displacing even deeply and firmly embedded objects that are sensitive to its action. Most of the implants used in the human body do not have such properties, but if they are located in the vicinity of the examined area, they can cause distortion of the magnetic field and reduce the diagnostic value of the obtained images. The examination usually takes quite a long time (20-60 minutes), and the patient is in a narrow chamber, where unpleasant noises can also be heard, therefore a contraindication may be, for example, claustrophobia or the subject's lack of cooperation (artifacts due to movement). Often there is a need for intravenous administration of a contrast agent, therefore hypersensitivity to gadolinium contrast agents is a contraindication. It should be emphasized that the reactions related to hypersensitivity to contrast agents in MRI are milder and less frequent than to iodine contrast agents used in therefore, hypersensitivity to gadolinium contrast agents is a contraindication. It should be emphasized that the reactions related to hypersensitivity to contrast agents in MRI are milder and less frequent than to iodine contrast agents used in therefore, hypersensitivity to gadolinium contrast agents is a contraindication. It should be emphasized that the reactions related to hypersensitivity to contrast agents in MRI are milder and less frequent than to iodine contrast agents used inin computed tomography [8,10,12].

The indications for the examination are numerous, they include many different diseases. Due to the nature of MRI that focuses primarily on hydrogen, significant limitations in the use of this imaging method exist in the diagnosis of lung disease. The aerated lung parenchyma contains a negligible amount of water, and hence hydrogen, therefore the examination is reserved only for specific indications, such as determining the degree of tumor infiltration into the chest wall or mediastinal structures in order to plan surgical treatment. On the other hand, MRI is successfully used in the diagnosis of mediastinal diseases, including heart diseases [7, 12].

When it comes to the assessment of organs - heart, brain, spine, spinal canal, joints, small pelvis, prostate, breast - MRI is perhaps the most accurate imaging method. In addition, it is a very sensitive method, because it allows to detect even small changes, and functional - for example, blood flow through the tissue (so-called magnetic resonance perfusion) and biochemical parameters can be determined (so-called magnetic resonance spectroscopy).

MRI can also be used to assess, for example, the fibers of the white matter of the brain (the so-called magnetic resonance diffusion tensor). This is not seen in other studies. Functional magnetic resonance imaging is also a fascinating method. It consists in examining the functions of the cerebral cortex during specific activities of the patient. On this basis, it can be assessed whether, for example, excision of a tumor in the brain will be safe for the functioning of this part of it,

Since the implementation of magnetic resonance imaging in medical diagnostics in 1977, it has become the basic method in neurological and orthopedic diagnostics. Until recently, the use of MRI in cardiological diagnostics was limited due to difficulties in imaging a moving organ such as the beating human heart. In recent years, MR scanners with high speed of examination registration have been developed, which enabled imaging of the morphology, function, blood flow in the heart and the large vessels surrounding it, and thus a global assessment of cardiological health [7,9].

Cardiac MRI allows for the identification of damage to the heart muscle after the infarction, diagnosis of congenital heart defects and diseases of large vessels. Cardiac MRI may also be used to perform a stress test and assess the blood supply to the heart muscle at rest and post-stress to determine whether coronary stenosis identified by coronary angiography or computed tomography is significant or not. All elements of the cardiovascular system can be imaged in MRI: veins, atria, atrioventricular valves, chambers, arteries, which makes MRI useful in the assessment of complex and complex heart diseases. The advantage of MRI is the possibility of three-dimensional imaging of the anatomy of the heart and large vessels without exposing the patient to ionizing radiation [5,7,12].

One of the newest diagnostic techniques used in medicine in recent years is spectroscopy (MRS). It allows for non-invasive study of tissue metabolism by examining the spectra of metabolites. The most commonly used are proton and phosphor spectroscopy. Oncological spectroscopy has a recognized application in the diagnosis of central nervous system neoplasms (including brain tumors). The value of MR spectroscopy is the evaluation of the signal of biochemical compounds, which is helpful in differentiating neoplasms, assessing the degree of malignancy and detecting recurrence. Both studies using MR spectroscopy and diffusion allow for the assessment of tumor metabolism and the effectiveness of the applied therapy [3,4,5].

Although imaging diagnostics devices of different generations are apparently similar to each other, their capabilities are also evidenced by specialized licenses for various operating modes (the so-called license keys), which constitute a significant part of the value of the entire device and, in special cases, have a total value of even several million zlotys. Optimizing the use of such devices consists not only in mastering the image creation functions, but also in the use of advanced software for post-processing of the obtained image data. The diagnostic value of magnetic resonance imaging in oncology depends not only on the class and parameters of the apparatus itself, but also on its software and, above all, on the knowledge and experience of people who operate and describe the performed MRI [1,2,6].

Depending on the type of examination and the area studied, the examination may be performed without preparation or a 2-hour fasting period is required. This time may be longer, especially when the examination concerns the gastrointestinal tract or biliary tract. In the case of general anesthesia, it should be 6 hours. on an empty stomach before the examination. If the pelvis is examined, the bladder should be moderately full. On the day of the examination, medication should be taken as usual, washed down with a little water [1,9,11].

The breast examination should be performed between the 6th and 13th day of the cycle (even if she is using contraception). In the case of using hormone replacement therapy, it is recommended to perform the test 4 weeks after its discontinuation. Documentation of previous imaging examinations (eg USG, X-ray, CT) should also be brought to the examination. A comparison with previous tests can often make a more accurate diagnosis. The examined area should be clean, devoid of cosmetics, the composition of which may also cause distortions of the magnetic field. This especially applies to makeup and hairspray in cases of head examination. You should report for the test well in advance, at least 30 minutes, because then there will be time to ask about the details of the test, as well as to fill in the questionnaire on your general health and operations, possibly the presence of metal foreign bodies. All metal objects, magnetic cards, jewelry, even those located in a part of the body far away from the examination area, should be left in the changing room. If contrast is to be administered for the test, the nurse will insert a cannula into the patient. The patient is then placed on a narrow examination table. Depending on the type of apparatus, it may be an open system apparatus with access to the tested person from three

sides, or in the case of systems with a stronger field and a wider range of tests performed in a narrow tunnel. During the examination, there are unpleasant noises, so more sensitive people should have earplugs in advance. The examined person receives a remote switch which can be used to stop the test at his own request. In some cases, after the first phase of the study, contrast is injected intravenously and the post-contrast part begins. During the examination, the technician may give instructions that must be strictly followed. The MRI of hospital-treated patients is usually available after the examination. In the case of outpatient examinations, it is usually necessary to wait a few days for the result [1,2,8].

The magnetic resonance method will develop in many directions. One of the directions will be to study the magnetic field of higher intensity than today. It produces excellent images, but it is not yet known if it will be safe. The next path of development will be increasingly refined functional studies, e.g. brain flows studied without the administration of a contrast agent (which has some side effects), only by observing moving hydrogen atoms. Technological progress is also heading towards better and better resolution, i.e. more precise and precise examination. Finally, another area is whole-body research, especially in cancer patients. Here, resonance is a method that competes with the otherwise excellent PET research, which uses ionizing radiation. It is the most important

Medical technologies are constantly evolving, and the next generations of equipment in the most advanced fields of imaging diagnostics appear every few years. Thanks to the latest advances in diagnostics with the use of magnetic resonance imaging, a comprehensive assessment of the health condition based on morphological and functional imaging of the entire human body is becoming more and more realistic. It is only a matter of time before the whole body method of magnetic resonance imaging (the so-called Whole Body MR) is propagated as a screening method, which allows to capture, for example, neoplastic focal lesions before any symptoms of cancer appear, and even earlier than the tumor markers in the blood serum are increased.

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