Functional MR Imaging (fMRI) – Brain

This information is reviewed by a physician with expertise in the area presented and is further reviewed by committees from the American College of Radiology (ACR) and the Radiological Society of North America (RSNA), comprising physicians with expertise in several radiologic areas.

What is Functional MR Imaging (fMRI) - Brain?

Magnetic resonance imaging (MRI) is a noninvasive medical test that helps physicians diagnose and treat medical conditions.

MR imaging uses a powerful magnetic field, radio frequency pulses and a computer to produce detailed pictures of organs, soft tissues, bone and virtually all other internal body structures. The images can then be examined on a computer monitor, printed or copied to CD. MRI does not use ionizing radiation (x-rays).

Detailed MR images allow physicians to better evaluate various parts of the body and certain diseases that may not be assessed adequately with other imaging methods such as x-ray, ultrasound or computed tomography (also called CT or CAT scanning).

Functional magnetic resonance imaging (fMRI) is a relatively new procedure that uses MR imaging to measure the tiny metabolic changes that take place in an active part of the brain.

What are some common uses of the procedure?

fMRI is becoming the diagnostic method of choice for learning how a normal, diseased or injured brain is working, as well as for assessing the potential risks of surgery or other invasive treatments of the brain.

Physicians perform fMRI to:

- examine the anatomy of the brain.
- determine precisely which part of the brain is handling critical functions such as thought, speech, movement and sensation, which is called brain mapping.
- help assess the effects of stroke, trauma or degenerative disease (such as Alzheimer's) on brain function.
- monitor the growth and function of brain tumors.
- guide the planning of surgery, radiation therapy, or other surgical treatments for the brain.

How should I prepare?

You may be asked to wear a gown during the exam or you may be allowed to wear your own clothing if it is loose-fitting and has no metal fasteners.

Guidelines about eating and drinking before an MRI exam vary with the specific exam and also with the facility. For some types of exams, you will be asked to fast for 8-12 hours. Unless you are told otherwise, you may follow your regular daily routine and take medications as usual.

Some MRI examinations may require the patient to swallow contrast material or receive an injection of contrast into the bloodstream. The radiologist or technologist may ask if you have allergies of any kind, such as allergy to iodine or x-ray contrast material, drugs, food, the environment, or asthma. However, the contrast material used for an MRI exam, called gadolinium, does not contain iodine and is less likely to cause side effects or an allergic reaction.

The radiologist should also know if you have any serious health problems or if you have recently had surgery. Some conditions, such as severe kidney disease may prevent you from being given contrast material for an MRI.

Women should always inform their physician or technologist if there is any possibility that they are pregnant. MRI has been used for scanning patients since the 1980's with no reports of any ill effects on pregnant women or their babies.

However, because the baby will be in a strong magnetic field, pregnant women should not have this exam unless the potential benefit from the MRI is assumed to outweigh the potential risks.

If you have claustrophobia (fear of enclosed spaces) or anxiety, you may want to ask your physician for a prescription for a mild sedative.

Jewelry and other accessories should be left at home if possible, or removed prior to the MRI scan. Because they can interfere with the magnetic field of the MRI unit, metal and electronic objects are not allowed in the exam room. These items include:

- jewelry, watches, credit cards and hearing aids, all of which can be damaged.
- pins, hairpins, metal zippers and similar metallic items, which can distort MRI images.
- removable dental work.
- pens, pocketknives and eyeglasses.
- body piercings.

In most cases, an MRI exam is safe for patients with metal implants, except for a few types. People with the following implants cannot be scanned and should not enter the MRI scanning area unless explicitly instructed to do so by a radiologist or technologist who is aware of the presence of any of the following:

- internal (implanted) defibrillator or pacemaker
- cochlear (ear) implant
- some types of clips used on brain aneurysms

You should tell the technologist if you have any medical or electronic devices in your body, because they may interfere with the exam or potentially pose a risk, depending on their nature and the strength of the MRI magnet. Examples include, but are not limited to:

- artificial heart valves
- implanted drug infusion ports
- implanted electronic device, including a cardiac pacemaker
- artificial limbs or metallic joint prostheses
- implanted nerve stimulators
- metal pins, screws, plates, stents or surgical staples

In general, metal objects used in orthopedic surgery pose no risk during MRI. However, a recently placed artificial joint may require the use of another imaging procedure. If there is any question of their presence, an x-ray may be taken to detect the presence and identify of any metal objects.

Patients who might have metal objects in certain parts of their bodies may also require an x-ray prior to an MRI.

Dyes used in tattoos may contain iron and could heat up during MRI, but this is rarely a problem. Tooth fillings and braces usually are not affected by the magnetic field but they may distort images of the facial area or brain, so the radiologist should be aware of them.

What does the equipment look like?

The traditional MRI unit is a large cylinder-shaped tube surrounded by a circular magnet. You will lie on a moveable examination table that slides into the center of the magnet.

Some MRI units, called short-bore systems, are designed so that the magnet does not completely surround you; others are open on the sides ("low-strength" open MRI). 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 may provide high quality images for many types of exams; however, open MRI units with older magnets may not provide this same quality. Certain types of exams cannot be performed using open MRI. For more information, consult your doctor.

The computer workstation that processes the imaging information is located in a separate room than the scanner.

How does the procedure work?

Unlike conventional x-ray examinations and computed tomography (CT) scans, MRI does not depend on ionizing radiation. Instead, while in the magnet, radio waves redirect the axes of spinning protons, which are the nuclei of hydrogen atoms, in a strong magnetic field.

The magnetic field is produced by passing an electric current through wire coils in most MRI units. Other coils, located in the machine and in some cases, placed around the part of the body being imaged, send and receive radio waves, producing signals that are detected by the coils.

A computer then processes the signals and generates a series of images each of which shows a thin slice of the body. The images can then be studied from different angles by the interpreting physician.

Overall, the differentiation of abnormal (diseased) tissue from normal tissues is often better with MRI than with other imaging modalities such as x-ray, CT and ultrasound.

In an fMRI examination, you will perform a particular task during the imaging process, causing increased metabolic activity in the area of the brain responsible for the task. This activity, which includes expanding blood vessels, chemical changes and the delivery of extra oxygen, can then be recorded on MRI images.

How is the procedure performed?

MRI examinations may be performed on outpatients or inpatients.

You will be positioned on the moveable examination table. Straps and bolsters may be used to help you stay still and maintain the correct position during imaging.

Small devices that contain coils capable of sending and receiving radio waves may be placed around or adjacent to the area of the body being studied.

For fMRI, your head may be placed in a brace designed to help hold it still. This brace may include a mask that is created especially for you. You may be given special goggles and/or earphones to wear, so that audio-visual stimuli (for example, a projection from a computer screen or recorded sounds) may be administered during the scan.

If a contrast material will be used in the MRI exam, a nurse or technologist will insert an intravenous (IV) line into a vein in your hand or arm. A saline solution may be used. The solution will drip through the IV to prevent blockage of the IV line until the contrast material is injected.

You will be moved into the magnet of the MRI unit and the radiologist and technologist will leave the room while the MRI examination is performed.

During an fMRI exam, you will be asked to perform a number of small tasks, such as tapping your thumb against each of the fingers on the same hand, rubbing a block of sandpaper, or answering simple questions.

If a contrast material is used during the examination, it will be injected into the intravenous line (IV) after an initial series of scans. Additional series of images will be taken during or following the injection.

When the examination is completed, you may be asked to wait until the technologist or radiologist checks the images in case additional images are needed.

Your intravenous line will be removed.

MRI exams generally include multiple runs (sequences), some of which may last several minutes.

The entire examination is usually completed within 45 minutes.

MR spectroscopy, which provides additional information on the chemicals present in the body's cells, may also be performed during the MRI exam and may add approximately 15 minutes to the exam time.

What will I experience during and after procedure?

Most MRI exams are painless.

Some patients, however, find it uncomfortable to remain still during MR imaging. Others experience a sense of being closed-in (claustrophobia). Therefore, sedation can be arranged for those patients who anticipate anxiety, but fewer than one in 20 require it.

It is normal for the area of your body being imaged to feel slightly warm, but if it bothers you, notify the radiologist or technologist. It is important that you remain perfectly still while the images are being recorded, which is typically only a few seconds to a few minutes at a time. For some types of exams, you may be asked to hold your breath. You will know when images are being recorded because you will hear tapping or thumping sounds when the coils that generate the radiofrequency pulses are activated. You will be able to relax between imaging sequences, but will be asked to maintain your position as much as possible.

You will usually be alone in the exam room during the MRI procedure. However, the technologist will be able to see, hear and speak with you at all times using a two-way intercom. Many MRI centers allow a friend or parent to stay in the room as long as they are also screened for safety in the magnetic environment.

You may be offered or you may request earplugs to reduce the noise of the MRI scanner, which produces loud thumping and humming noises during imaging. MRI scanners are air-conditioned and well-lit. Some scanners have music to help you pass the time.

When the contrast material is injected, it is normal to feel coolness and a flushing sensation for a minute or two. The intravenous needle may cause you some discomfort when it is inserted and once it is removed, you may experience some bruising. There is also a very small chance of irritation of your skin at the site of the IV tube insertion.

If you have not been sedated, no recovery period is necessary. You may resume your usual activities and normal diet immediately after the exam. A few patients experience side effects from the contrast material, including nausea and local pain. Very rarely, patients are allergic to the contrast material and experience hives, itchy eyes or other reactions. If you experience allergic symptoms, a radiologist or other physician will be available for immediate assistance.

Manufacturers of intravenous contrast indicate mothers should not breast feed their babies for 24–48 hours after contrast medium is given. However, both the American College of Radiology (ACR) and the European Society of Urogenital Radiology note that the available data suggest that it is safe to continue breast-feeding after receiving intravenous contrast. The Manual on Contrast Media from the ACR states:

"Review of the literature shows no evidence to suggest that oral ingestion by an infant of the tiny amount of gadolinium contrast medium excreted into breast milk would cause toxic effects. We believe, therefore, that the available data suggest that it is safe for the mother and infant to continue breast-feeding after receiving such an agent.

If the mother remains concerned about any potential ill effects, she should be given the opportunity to make an informed decision as to whether to continue or temporarily abstain from breast-feeding after receiving a gadolinium contrast medium. If the mother so desires, she may abstain from breast-feeding for 24 hours with active expression and discarding of breast milk from both breasts during that period. In anticipation of this, she may wish to use a breast pump to obtain milk before the contrast study to feed the infant during the 24-hour period following the examination."

Who interprets the results and how do I get them?

A radiologist, a physician specifically trained to supervise and interpret radiology examinations, will analyze the images and send a signed report to your primary care or referring physician, who will share the results with you.

What are the benefits vs. risks?

Benefits

- MRI is a noninvasive imaging technique that does not involve exposure to ionizing radiation.
- MRI can help physicians evaluate both the structure of an organ and how it is working.
- MRI enables the discovery of abnormalities that might be obscured by bone with other imaging methods.
- fMRI enables the detection of abnormalities of the brain, as well as the assessment of the normal functional anatomy of the brain, which cannot be accomplished with other imaging techniques.

Risks

- The MRI examination poses almost no risk to the average patient when appropriate safety guidelines are followed.
- If sedation is used there are risks of excessive sedation. The technologist or nurse monitors your vital signs to minimize this risk.
- Although the strong magnetic field is not harmful in itself, implanted medical devices that contain metal may malfunction or cause problems during an MRI exam.
- There is a very slight risk of an allergic reaction if contrast material is injected. Such reactions usually are mild and easily controlled by medication. If you experience allergic symptoms, a radiologist or other physician will be available for immediate assistance.
- Nephrogenic systemic fibrosis is currently a recognized, but rare, complication of MRI believed to be caused by the injection of high doses of MRI contrast material in patients with very poor kidney function.

What are the limitations of fMRI of the Brain?

High-quality images are assured only if you are able to remain perfectly still or hold your breath, if requested to do so, while the images are being recorded. If you are anxious, confused or in severe pain, you may find it difficult to lie still during imaging.

A person who is very large may not fit into the opening of a conventional MRI machine.

The presence of an implant or other metallic object sometimes makes it difficult to obtain clear images and patient movement can have the same effect.

MRI generally is not recommended for patients who have been acutely injured; however, this is a clinical judgment. This is because traction devices and many types of life support equipment must be kept away from the area to be imaged. Furthermore, the examination takes longer than other imaging modalities (typically x-ray and CT) and the results may not be immediately available as is often necessary in trauma situations.

Although there is no reason to believe that magnetic resonance imaging harms the fetus, pregnant women usually are advised not to have an MRI exam unless medically necessary.

MRI typically costs more and may take more time to perform than other imaging modalities.

Functional MRI is still evolving and improving. While it appears to be as accurate in finding the location of brain activity as any other method, overall there is less experience with fMRI than with many other MRI techniques. Your physician may recommend additional tests to confirm the results of fMRI if there are critical decisions to be made (such as in planning brain surgery).