Magnetic Resonance, Functional (fMRI) - Brain

Functional magnetic resonance imaging (fMRI) measures the small changes in blood flow that occur with brain activity. It may be used to examine the brain's functional anatomy, (determine which parts of the brain are handling critical functions), evaluate the effects of stroke or other disease, or to guide brain treatment. fMRI may detect abnormalities within the brain that cannot be found with other imaging techniques.

Tell your doctor about any health problems, recent surgeries, or allergies, and whether there's a possibility you are pregnant. The magnetic field is not harmful, but it may cause some medical devices to malfunction. Most orthopedic implants pose no risk, but you should always tell the technologist if you have any devices or metal in your body. Guidelines about eating and drinking before your exam vary between facilities. Unless you are told otherwise, take your regular medications as usual and try to maintain your typical habits for drinking caffeinated beverages (especially coffee). For example, if you normally drink coffee every morning, try not to skip it on the day of your exam. If you rarely drink coffee, try to avoid it on the day of your exam. If you rarely drink coffee, try to avoid it on the day of your exam. Leave jewelry at home and wear loose, comfortable clothing. You may be asked to wear a gown. If you have claustrophobia or anxiety, you may want to ask your doctor for a mild sedative prior to the exam.

What is Functional MR Imaging (fMRI) - Brain?

Magnetic resonance imaging (MRI) is a noninvasive test used to diagnose medical conditions.

MRI uses a powerful magnetic field, radio waves and a computer to produce detailed pictures of internal body structures. MRI does not use radiation (x-rays).

Detailed MR images allow doctors to examine the body and detect disease. The images can be reviewed on a computer monitor. They may also be sent electronically, printed or copied to a CD, or uploaded to a digital cloud server.

Functional magnetic resonance imaging (fMRI) uses MR imaging to measure the tiny changes in blood flow 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 functional anatomy of the brain.
- determine 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 invasive treatments for the brain.

How should I prepare?

You may need to wear a hospital gown. 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 vary between specific exams and facilities. Unless you are told otherwise, take food and medications as usual.

Some MRI exams use an injection of contrast material. You may be asked if you have asthma or allergies to iodine contrast material, drugs, food, or the environment. MRI exams commonly use a contrast material called gadolinium. Gadolinium can be used in patients with iodine contrast allergy. A patient is much less likely to be allergic to gadolinium contrast than to iodine contrast. However, even if the patient has a known allergy to gadolinium, it may be possible to use it after appropriate pre-medication. For more information on allergic reactions to gadolinium contrast, please consult the ACR Manual on Contrast Media. Gadolinium can be used in patients with iodine contrast allergy. A patient is much less likely to be allergic to gadolinium contrast than to iodine contrast. However, even if the patient has a known allergy to gadolinium, it may be possible to use it after appropriate pre-medication. For more information on allergic reactions to gadolinium contrast, please consult the ACR Manual on Contrast Media (https://www.acr.org/Clinical-Resources/Contrast-Manual).

Tell the technologist or radiologist if you have any serious health problems or recently had surgery. Some conditions, such as severe kidney disease, may require the use of specific types of gadolinium contrast that are considered safe for patients with kidney disease. You may need a blood test to determine whether your kidneys are functioning normally.

Women should always tell their doctor and technologist if there is a chance they are pregnant. MRI has been used since the 1980s with no reports of any ill effects on pregnant women or their unborn babies. However, the baby will be in a strong magnetic field. Therefore, pregnant women should not have an MRI in the first trimester unless the benefit of the exam clearly outweighs any potential risks. Pregnant women should not receive gadolinium contrast unless absolutely necessary. See the MRI Safety During Pregnancy (https://www.radiologyinfo.org/en/info/safety-mri-pregnancy) page for more information about pregnancy and MRI.

If you have claustrophobia (fear of enclosed spaces) or anxiety, you may want to ask your doctor to prescribe a mild sedative prior to your exam.

Leave all jewelry and other accessories at home or remove them prior to the MRI scan. Metal and electronic items can interfere with the magnetic field of the MRI unit, and they are not allowed in the exam room. They may cause burns or become harmful projectiles within the MRI scanner 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, pocket knives and eyeglasses
• body piercings
• mobile phones, electronic watches and tracking devices.
In most cases, an MRI exam is safe for patients with metal implants, except for a few types. People with the following implants may not be scanned and should not enter the MRI scanning area without first being evaluated for safety:

- some cochlear (ear) implants
- some types of clips used for brain aneurysms
- some types of metal coils placed within blood vessels
- some older cardiac defibrillators and pacemakers

Tell the technologist if you have medical or electronic devices in your body. These devices may interfere with the exam or pose a risk. Many implanted devices will have a pamphlet explaining the MRI risks for that particular device. If you have the pamphlet, bring it to the attention of the scheduler before the exam. MRI cannot be performed without confirmation and documentation of the type of implant and MRI compatibility. You should also bring any pamphlet to your exam in case the radiologist or technologist has any questions.

If there is any question, an x-ray can detect and identify any metal objects. Metal objects used in orthopedic surgery generally pose no risk during MRI. However, a recently placed artificial joint may require the use of a different imaging exam.

Tell the technologist or radiologist about any shrapnel, bullets, or other metal that may be in your body. Foreign bodies near and especially lodged in the eyes are very important because they may move or heat up during the scan and cause blindness. Dyes used in tattoos may contain iron and could heat up during an MRI scan. This is rare. Tooth fillings, braces, eyeshadows and other cosmetics usually are not affected by the magnetic field. However, they may distort images of the facial area or brain. Tell the radiologist about 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 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. Some newer MRI machines have a larger diameter bore, which can be more comfortable for larger patients or those with claustrophobia. "Open" MRI units are open on the sides. They are especially helpful for examining larger patients or those with claustrophobia. Open MRI units can provide high quality images for many types of exams. Certain exams cannot be performed using open MRI. For more information, consult your radiologist.

**How does the procedure work?**

Unlike x-ray and computed tomography (CT) exams, MRI does not use radiation. Instead, radio waves re-align hydrogen atoms that naturally exist within the body. This does not cause any chemical changes in the tissues. As the hydrogen atoms return to their usual alignment, they emit different amounts of energy depending on the type of body tissue they are in. The scanner captures this energy and creates a picture using this information.

In most MRI units, the magnetic field is produced by passing an electric current through wire coils. Other coils are located in the machine and, in some cases, are placed around the part of the body being imaged. These coils send and receive radio waves, producing signals that are detected by the machine. The electric current does not come in contact with the patient.

A computer processes the signals and creates a series of images, each of which shows a thin slice of the body. These images can be studied from different angles by the radiologist.

MRI is able to tell the difference between diseased tissue and normal tissue better than x-ray, CT and ultrasound.

In an fMRI examination, you will perform one or more tasks during the imaging process, such as tapping your fingers or toes,
pursing your lips, wiggling your tongue, reading, viewing pictures, listening to speech and/or playing simple word games. This will cause increased metabolic activity in the areas of the brain responsible for these tasks. 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 exams may be done on an outpatient basis.

You will be positioned on the moveable exam table. Straps and bolsters may be used to help you stay still and maintain your position.

Devices that contain coils capable of sending and receiving radio waves may be placed around or next to the area of the body being scanned.

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

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 is used, a doctor, nurse or technologist will insert an intravenous catheter (IV line) into a vein in your hand or arm that will be used to inject the contrast material.

You will be placed into the magnet of the MRI unit. The technologist will perform the exam while working at a computer outside of the room.

When the exam is complete, you may be asked to wait while the radiologist checks the images in case more are needed.

Your IV line will be removed after the exam is over.

The entire examination is usually completed within one hour.

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

**What will I experience during and after the procedure?**

Most MRI exams are painless. However, some patients find it uncomfortable to remain still. Others may feel closed-in (claustrophobic) while in the MRI scanner. The scanner can be noisy. Sedation may be arranged for anxious patients, 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. Children will be given appropriately sized earplugs or headphones during the exam. 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.

Who interprets the results and how do I get them?

A radiologist, a doctor trained to supervise and interpret radiology exams, will analyze the images. The radiologist will 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 radiation.
- MRI can help physicians evaluate both the structure of an organ and how it is working.
- MRI can detect 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 exam poses almost no risk to the average patient when appropriate safety guidelines are followed.
- If sedation is used, there is a risk of using too much. However, your vital signs will be monitored to minimize this risk.
- The strong magnetic field is not harmful. However, it may cause implanted medical devices to malfunction or cause distortion of the images.
- Nephrogenic systemic fibrosis is a recognized, but rare, complication related to injection of gadolinium contrast. It usually occurs in patients with serious kidney disease. Your doctor will carefully assess your kidney function before considering a contrast injection.
- There is a very slight risk of an allergic reaction if contrast material is used. Such reactions are usually mild and controlled by medication. If you have an allergic reaction, a doctor will be available for immediate assistance.
- IV contrast manufacturers indicate mothers should not breastfeed their babies for 24-48 hours after contrast material is given. However, the most recent American College of Radiology (ACR) Manual on Contrast Media reports that studies show the amount of contrast absorbed by the infant during breastfeeding is extremely low. For further information please consult the ACR Manual on Contrast Media (https://www.acr.org/Clinical-Resources/Contrast-Manual) and its references.

What are the limitations of fMRI of the Brain?
High-quality images depend on your ability to remain perfectly still and follow breath-holding instructions 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 certain types of MRI machines. There are weight limits on the scanners.

Implants and other metallic objects can make it difficult to obtain clear images. Patient movement can have the same effect.

A very irregular heartbeat may affect the quality of images. This is because some techniques time the imaging based on the electrical activity of the heart.

MRI is generally not recommended for seriously injured patients. However, this decision is based on clinical judgment. This is because traction devices and life support equipment may distort the MR images. As a result, they must be kept away from the area to be imaged. Some trauma patients, however, may need MRI.

Although there is no reason to believe that MRI harms the fetus, pregnant women should not have an MRI exam during their first trimester unless medically necessary.

MRI typically costs more and may take more time to perform than other imaging methods. Talk to your insurance provider if you have concerns about the cost of MRI.

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 make (such as in planning brain surgery).

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