



## Magnetic Resonance Imaging (MRI) - Cardiac (Heart)

Cardiac magnetic resonance imaging (MRI) uses a powerful magnetic field, radio waves and a computer to produce detailed pictures of the structures within and around the heart. Cardiac MRI is used to detect or monitor cardiac disease and to evaluate the heart's anatomy and function in patients with both heart disease present at birth and heart diseases that develop after birth. Cardiac MRI does not use ionizing radiation to produce images, and it may provide the best images of the heart for certain conditions.



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 MRI 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. Leave all jewelry at home and wear loose, comfortable clothing. You may be asked to wear a hospital gown during the exam. If you have claustrophobia or anxiety, you may want to ask your doctor for a mild sedative prior to the exam.

### What is Cardiac MRI?

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.

### What are some common uses of the procedure?

Cardiac MRI is performed to help your physician detect or monitor cardiac disease by:

- evaluating the anatomy and function of the heart chambers, heart valves, size of and blood flow through major vessels, and the surrounding structures such as the pericardium (the sac that surrounds the heart).
- diagnosing a variety of cardiovascular (heart and/or blood vessel) disorders such as tumors, infections, and inflammatory conditions.
- evaluating the effects of coronary artery disease such as limited blood flow to the heart muscle and scarring within the heart muscle after a heart attack.
- planning a patient's treatment for cardiovascular disorders.
- monitoring the progression of certain disorders over time.
- evaluating the effects of surgical changes, especially in patients with congenital heart disease.
  
- evaluating the anatomy of the heart and blood vessels in children and adults with congenital heart disease (heart disease present at birth).

## 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.

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 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.

Infants and young children often require sedation or anesthesia to complete an MRI exam without moving. This depends on the child's age, intellectual development and the type of exam. Sedation can be provided at many facilities. A specialist in pediatric sedation or anesthesia should be available during the exam for your child's safety. You will be told how to prepare your child.

Some facilities may have personnel who work with children to help avoid the need for sedation or anesthesia. They prepare children by showing them a dummy MRI scanner and playing the noises they might hear during the exam. They also answer any questions and explain the procedure to relieve anxiety. Some facilities also provide goggles or headsets so the child can watch a movie while the scan is being done. This helps the child stay still and allows for good quality images.

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.

Anyone accompanying a patient into the exam room must also be screened for metal objects and implanted devices.

## 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.

## 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.

Electrocardiogram (ECG) leads (small sticky patches) will likely be placed on your chest to help the MRI machine synchronize the image acquisition with the beating of your heart. Men may require a small area of hair to be shaved from the chest in order to ensure that the small ECG patches will stick well. A respiratory gating belt, a device that helps the computer know how you are breathing at any given time, may be placed around your upper abdomen. Additionally, a small pulse monitor may be placed on your finger.

You will be given breathing instructions and will be asked to hold your breath for short periods of time during the examination.

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.

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

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 in less than 90 minutes once imaging has started, but may be shorter or longer depending on what the images show.

If a child has been sedated or anesthetized for an MRI exam, recovery time ranges from approximately 30 minutes to two hours after the exam is completed.

## 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.

During cardiac MRI, your heart beat will be monitored and you will be asked to hold your breath for short periods of time while images are recorded.

It is normal for the area of your body being imaged to feel slightly warm. If it bothers you, tell the radiologist or technologist. It is important that you remain perfectly still while the images are being taken. This is typically only a few seconds to a few minutes at a time. You will know when images are being recorded because you will hear and feel loud tapping or thumping sounds. These are made when the coils that generate the radio waves are activated. You will be provided with earplugs or headphones to reduce the sounds made by the scanner. You may be able to relax between imaging sequences. However, you will be asked to keep the same position without moving as much as possible.

You will usually be alone in the exam room. However, the technologist will be able to see, hear and speak with you at all times using a two-way intercom. Many facilities allow a friend or parent to stay in the room if they have also been screened for safety.

Children will be given appropriately sized earplugs or headphones during the exam. MRI scanners are air-conditioned and well-lit. Music may be played through the headphones to help pass the time.

In some cases, IV injection of contrast material may be given before the images are obtained. The IV needle may cause you some discomfort and you may experience some bruising. There is also a very small chance of skin irritation at the site of the IV tube insertion. Some patients may have a temporary metallic taste in their mouth after the contrast injection.

If you do not require sedation, no recovery period is necessary. You may resume your usual activities and normal diet immediately after the exam. On very rare occasions, a few patients experience side effects from the contrast material. These may include nausea, headache and pain at the site of injection. It is very rare that patients experience hives, itchy eyes or other allergic reactions to the contrast material. If you have allergic symptoms, tell the technologist. A radiologist or other doctor 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.

Follow-up exams may be needed. If so, your doctor will explain why. Sometimes a follow-up exam is done because a potential abnormality needs further evaluation with additional views or a special imaging technique. A follow-up exam may also be done to see if there has been any change in an abnormality over time. Follow-up exams are sometimes the best way to see if treatment is working or if an abnormality is stable or has changed.

## What are the benefits vs. risks?

## Benefits

- MRI is a noninvasive imaging technique that does not involve exposure to radiation.
- MR images of the heart are better than other imaging methods for certain conditions. This advantage makes MRI an invaluable tool in early diagnosis and evaluation of certain cardiac abnormalities, especially those involving the heart muscle.
- MRI has proven valuable in diagnosing a broad range of conditions, including cardiovascular anatomical anomalies (e.g., congenital heart defects), functional abnormalities (e.g., valve failure), tumors, and conditions related to coronary artery disease and cardiomyopathy (disease affecting the heart muscle).
- MR imaging can be used during certain interventional procedures, such as catheter-based ablation procedures to treat irregular heart rhythms, including atrial fibrillation. The use of MRI can substantially shorten the time required to perform these procedures and result in improved accuracy.
- MRI can detect abnormalities that might be obscured by bone with other imaging methods.
- The MRI gadolinium contrast material is less likely to cause an allergic reaction than the iodine-based contrast materials used for x-rays and CT scanning.
- Cardiac MRI allows for evaluation of the structures and function of the heart and major vessels without the risks of exposure to ionizing radiation which may be associated with more invasive procedures or some other non-invasive tests.

## 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 and its references.

## What are the limitations of a Cardiac MRI?

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.

The constant motion of the heart creates challenges in obtaining clear images. These challenges can be overcome by various techniques including synchronizing the imaging with ECG tracing, synchronizing the imaging with breathing, or having you perform repeated short breath holds during imaging.

An irregular heartbeat or atrial fibrillation (which makes cardiac motion and heart rate unpredictable) may cause difficulties in acquiring cardiac MR images.

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.

Acquiring detailed images of the coronary arteries and their branches is more difficult with MRI than with other imaging modalities. Therefore coronary artery imaging is most often done with cardiac CT or a more invasive procedure using a catheter placed into the blood vessels via the groin or arm.

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.

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