



Magnetic Resonance Imaging (MRI) - Cardiac (Heart)

What is Cardiac MRI?

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

MRI 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, transmitted electronically, printed or copied to a CD. MRI does not use ionizing radiation (x-rays).

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

What are some common uses of the procedure?

Cardiac MRI imaging is performed to help:

- evaluate the anatomy and function of the heart, valves, major vessels, and surrounding structures (such as the surrounding pericardial sac).
- diagnose a variety of cardiovascular (heart and/or blood vessel) problems.
- detect and evaluate the effects of coronary artery disease.
- plan a patient's treatment for cardiovascular problems and monitor a patient's progress over time.

- evaluate the anatomy of the heart and blood vessels in children with congenital cardiovascular disease.

Using cardiac MRI, physicians can:

- examine the size of the heart chambers and the thickness of the heart wall.
- determine the extent of myocardial (heart muscle) damage caused by a heart attack or progressive heart disease.
- detect the buildup of plaque and blockages in blood vessels.
- assess a patient's recovery following treatment.

- assess the heart anatomy, muscle function, heart valve function and vascular blood flow both before and after surgical repair of congenital cardiovascular disease in children.

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. Unless you are told otherwise, you may follow your regular daily routine and take food and medications as usual.

Some MRI examinations may require the patient to receive an injection of contrast material 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 most commonly 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. If there is a history of kidney disease, it may be necessary to perform a blood test to determine whether the kidneys are functioning adequately.

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 1980s 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 exam is assumed to outweigh the potential risks. Pregnant women should not receive injections of contrast material. See the Safety page (www.RadiologyInfo.org/en/safety/) for more information about pregnancy and MRI.

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

Infants and young children usually require sedation or anesthesia to complete an MRI exam without moving. Whether a child requires sedation will depend on the child's age and the type of exam being performed. Moderate and conscious sedation can be provided at most facilities. A physician or nurse specializing in the administration of sedation or anesthesia to children will be available during the exam to ensure your child's safety. You will be given special instructions how to prepare your child for the sedation or anesthesia.

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
- some types of metal coils placed within blood vessels

You should tell the technologist if you have 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 of and identify 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. You should notify the technologist or radiologist of any shrapnel, bullets, or other pieces of metal which may be present in your body due to accidents. 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.

Parents who accompany children into the scanning room also need to remove metal objects and notify the technologist of any medical or electronic devices they may have.

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 (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 provide very high quality images for many types of exams; however, open MRI units with older magnets may not provide



this same image quality. Certain types of exams cannot be performed using open MRI. For more information, consult your radiologist.

The computer workstation that processes the imaging information is located in a separate room from 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 radiologist.

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

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.

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.

Electrocardiogram (ECG) leads may be placed on your chest to help the machine image acquisition with the beating of your heart. 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.

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.

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 60 to 90 minutes once imaging has started.

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.

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 the procedure?

Most MRI exams are painless. However, some patients 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 without movement 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. Some patients may sense a metallic taste in their mouth after the contrast injection.

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, notify the technologist. A radiologist or other physician will be available for immediate assistance.

Manufacturers of intravenous contrast indicate mothers should not breastfeed 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

breastfeeding after receiving intravenous contrast. The ACR Manual on Contrast Media 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 breastfeeding 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 breastfeeding after receiving a gadolinium contrast medium. If the mother so desires, she may abstain from breastfeeding 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."

For further information please consult the ACR Manual on Contrast Media and its references. (www.acr.org/SecondaryMainMenuCategories/quality_safety/contrast_manual.aspx)

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.

Follow-up examinations are often necessary, and your doctor will explain the exact reason why another exam is requested. Sometimes a follow-up exam is done because a suspicious or questionable finding needs clarification with additional views or a special imaging technique. A follow-up examination may be necessary so that any change in a known abnormality can be detected over time. Follow-up examinations are sometimes the best way to see if treatment is working or if an abnormality is stable over time.

What are the benefits vs. risks?

Benefits

- MRI is a noninvasive imaging technique that does not involve exposure to ionizing radiation.
- MRI images of the heart are generally clearer than with some 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 cardiac anatomical anomalies (e.g., congenital defects), functional abnormalities (e.g., valve failure), tumors and conditions related to decreased blood flow.
- 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.

- The contrast material used in MRI exams is less likely to produce an allergic reaction than the iodine-based contrast materials used for conventional x-rays and CT scanning.
- Cardiac MRI allows physicians to examine the structures and function of the heart and major vessels without risks like exposure to radiation typically associated with traditional, more invasive procedures.

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 gadolinium contrast material in patients with very poor kidney function.

What are the limitations of a Cardiac MRI?

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. Patient movement can have the same effect.

The constant motion of the heart creates a difficulty in obtaining good imaging, which can be overcome by various imaging techniques (synchronizing the imaging with ECG tracing, etc.)

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.

Acquiring detailed images of the coronary arteries and their branches is more difficult with MRI than with cardiac CT or invasive coronary angiography.

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

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