

<b>Title</b>	Diagnostic Magnetic Resonance Imaging (MRI)
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<b>Course No</b>	DMRI040109
<b>Contact Hour</b>	1

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## Purpose

This course describes principles, clinical uses, and techniques of diagnostic magnetic resonance imaging (MRI), and nursing considerations for preparing, transporting, and providing post-care for patients who receive these scans.

## Objectives

1. Identify clinical situations in which MRI scans are useful.
  2. Recognize currently evolving MRI techniques.
  3. Identify pre- and post-care of patients who receive MRI scans.
  4. Recognize conditions that contraindicate MRI scans.
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Magnetic resonance imaging (MRI) provides a versatile diagnostic tool for medical anatomical imaging. MRI scans create painless two and three-dimensional pictures of the human body's internal soft tissues and blood vessels without using ionizing radiation. MRI was originally called nuclear magnetic resonance imaging (NMRI) when it was developed in 1946. MRI scanning was introduced to the diagnostic medical community in 1980.

An MRI scanning instrument includes several main components--a large and powerful superconducting magnet, a table the patient lies on, a cage shield that excludes extraneous radio waves, an operator console, and a computer system that analyzes data and develops images. It also includes a cooling system that maintains the magnet's homogenous and stable magnetic field. An MRI scanning instrument is very complex and it is expensive to purchase and maintain.

MRI scans provide the advantage of avoiding ionizing radiation. They also produce a more finely detailed image of internal human anatomy than a computerized tomography (CT) scan or a standard x-ray image.

MRI scans employ a powerful, non-invasive magnetic field to develop detailed images of human organ systems. Human cells are primarily composed of hydrogen ions, which line up in the magnetic field during scans. Magnetic scanning bombards the aligned hydrogen ions with radiofrequency waves, causing the ions to emit signals the computer converts to visual images. The computer translates the reflective action of the tissue hydrogen nuclei (protons) to produce images of the soft tissues in the magnetic field.

CT and MRI scans are painless tests that define details of anatomical structures in the scanned body systems, but they have significant clinical differences. During the Emergency Department work-up to diagnose suspected strokes, non-contrast CT scans are currently recommended as the most effective scans for the first three hours after suspected cardiovascular events. They are superior tools for initially differentiating hemorrhagic strokes from ischemic strokes, even

though they expose patients to small amounts of ionizing radiation.

After three hours but within three days of these events, CT scans detect up to 79% of ischemic strokes, but MRI scans detect up to 95% of them. Thus, CT and MRI scans are valuable at different phases in the diagnosis and follow-up of patients who experience ischemic strokes.

MRI scans are also more helpful tools for diagnosing many other brain and nervous system structural and biochemical abnormalities. They provide the only modality that directly creates spinal cord images, enabling accurate diagnoses of many spinal conditions.

Cross-sectional MRI imaging of human body systems provides a vital tool for diagnosis and therapeutic treatment. They enable better detection and quicker visualization of many non-acute medical problems. They are well suited for evaluating the complex bone and soft tissue anatomy of musculoskeletal, neurological, and cardiovascular systems. They also provide a means to monitor and manage ongoing therapeutic treatment. For example, medical professionals often use MRI scans to determine tumor response to chemotherapy.

## **Contrast and Non-contrast MRI Scans**

Medical science continues to develop MRI scanning methods performed with and without intravenous contrast agents. Many types of MRI scans do not require administration of a contrast agent. Magnetic Resonance Angiography (MRA) is an example of a non-contrast MRI scan used to visualize blood vessels. It is based on the principle that water is the human body's largest source of hydrogen ions, and the tissues of the body have differing natural water content levels. During MRA scans various radio frequency pulses excite the hydrogen atoms and the energy they produce is used to create several types of MRI images. The two most common image types are produced by T1 and T2 proton densities. Manipulation of the time frame during the scan determines the type of image.

MRA scans use radiofrequency to detect blood moving through vessels, enabling non-invasive visualization of the cerebral, extra-cerebral and coronary vasculature. This technique is currently not as accurate as conventional angiography but is gaining in popularity because of its non-invasive nature. For patients who have known cerebral or coronary emboli, the risk of clots dislodging during traditional arteriography using arterial contrast is greater than during MRA, in which the contrast agent injections can be given through peripheral venous access.

MRI images are very clear and detailed and it was originally thought that contrast enhancement would not be needed for these scans. However, as it became more frequently used, medical scientists wanted to use it to study areas of the body where adjacent tissues have very similar water content and appearance. Contrast enhancement provides for adequate differentiation in these situations.

Now, several types of MRI scans include administration of contrast agent. A gadolinium arthrogram is an example of this type of non-invasive contrast MRI scan. It employs the metal ion gadolinium in contrast media for visualizing joint tissues. Because currently available MRI contrast agents contain small quantities of gadolinium they are commonly referred to by this name. Gadolinium has the potential for neurotoxicity so it is chemically bound to chelating agents that enable the body to eliminate it within one to two hours of administration. Gadolinium has a low incidence of allergies. It is metabolized by the liver and it crosses the placenta and enters breast milk.

Evolving MRI options include fast techniques, Diffusion-Weighted Imaging (DWI), Perfusion-Weighted imaging (PWI), and functional MRI (fMRI) studies. Current medical research extensively studies each of them, and standards for the techniques are not set and universally

available. Phased research studies of them are being conducted on patients with neurological and cardiac abnormalities. The techniques are also used in research projects that map the brain and heart, which provide a growing number of brain and heart reference atlases available in print and through the Internet ([www.loini.ucla.edu/ICBM](http://www.loini.ucla.edu/ICBM)).

## **Fast Techniques**

MRI techniques called Fast Techniques suppress flow artifact and improve imaging of vascular anatomy. Fluid attenuation inversion recovery (FLAIR) and fast low-angle shot (FLASH) are examples of two current MRI Fast Techniques. FLAIR is a special neurological technique applied during an MRI scan to improve the image contrast between brain tissue and cerebrospinal fluid. It is particularly useful in brain imaging for multiple sclerosis. FLASH is particularly useful for imaging the knee joints.

## **Diffusion-weighted imaging (DWI)**

DWI techniques detect random movements (diffusion) of water protons, enabling MRI images that reflect diffusion differences in tissues. Edematous tissues restrict the movement of the protons in their water molecules, making these tissues appear as bright areas on MRI scans. Within minutes of a stroke, DWI scans can detect changes caused by the stroke that other types of MRI images cannot detect. DWI scans can be performed in open MRI systems.

## **Perfusion-weighted imaging (PWI)**

PWI images identify perfusion or movement of contrast agent and fluids in tissues. This method can be extremely sensitive to cerebral ischemia just minutes after the onset of a stroke. After contrast agent is administered, PWI can provide detailed information about cerebral blood flow.

## **Functional MRI (fMRI)**

fMRI scans rely on relaxation characteristics exhibited by hydrogen ions in high concentrations in water. fMRI imaging techniques show regional changes in volumes and oxygenation in blood in the brain during specific motor and cognitive tasks. An advantage of these techniques is that they use standard MRI equipment. Current fMRI research is working to identify more effective contrast mechanisms.

Medical science continues to identify new MRI techniques. Diffusion Tensor Magnetic Resonance Imaging (DT-MRI) is the latest technique licensed by the National Institutes of Health (NIH). It enables researchers and physicians to visualize and diagnose a wide range of conditions by providing three-dimensional maps of nerve pathways in the brain and in heart muscle fibers and other soft tissues. More information about DT-MRI is available at <http://www.sciencedaily.com>.

## **Patient Preparation**

To obtain clear MRI images, patients must remove all metal objects and lie still during their scans. Nursing personnel properly prepares patients to ensure their cooperation for safe and successful scans. Nurses complete these essential screening procedures that screen patients scheduled for scans:

- Obtain an accurate patient weight.
- Obtain a complete medical history.

- Ask about the presence of pacemakers and pacemaker wires, intracoronary stents, neurostimulators, implanted devices, joint prostheses, and orthopedic hardware.
- Ensure that serum Blood Urea Nitrogen (BUN) and Creatinine (Cr) levels are WNL before patients undergo MRI scans using intravenous contrast agents.
- Identify the date of the last menstrual period in pre-menopausal women.
- Ask about the presence of intrauterine devices (IUDs) in pre-menopausal women.

Nurses also screen patients for these events and items to ensure safety:

- Surgeries involving metal plates, metal sutures, artificial heart valves, aneurysms, and clips in the brain
- Cochlear implants
- Hearing aids
- Eye injuries involving metallic foreign bodies
- Gunshot wounds (GSWs) with shrapnel or bullets remaining inside the body
- Tattooed eyeliner and certain other makeup

Regulators have determined that MRI scans can be performed on pregnant women when other non-ionizing forms of diagnostic imaging are inadequate, or they would expose women to ionizing radiation, like CTs do. Currently, no adverse effects from MRI scans are identified for pregnant women. However, it is still important to identify whether women are pregnant so they can consider the risks versus the benefits of MRI.

Critical care nurses can make arrangements for special non-metallic equipment so patients who receive life support can undergo MRI. Many MRI units also include monitoring capabilities for patients who are hemodynamically unstable. Intravenous (IV) pumps containing metal cannot be brought into the MRI room. Extra-long extension tubing enables IV pumps to remain outside the MRI room so patients can continue to receive IV fluids and medications during scanning.

Nurses should tell patients that they will be transported on stretchers to the department where MRIs are performed, and the scans usually take about 45 to 60 minutes. Patients usually wear hospital gowns only, and nurses should remind them to void before the scan to be more comfortable during the scanning time.

After patients arrive in the MRI suite they are transferred onto the scanner table and usually kept in a supine position. The MRI table is motorized, enabling it to move into the tube that contains the donut shaped magnet. Nurses should advise patients that they will hear a thumping noise during the scan. The scanner's magnetic coils pulse in the magnetic field, producing the thumping noise. Nurses should also advise patients to remain still during scanning to prevent distortion of scan images.

Some patients who undergo MRI scans experience claustrophobia, anxiety, or panic attacks, and about 3% to 5% of people cannot tolerate the scans because of this. Patient teaching about relaxation and deep breathing helps some patients prevent these reactions. Nurses should reassure patients that they can communicate with the MRI staff through a microphone in the scanner. Sympathetic MRI technicians who use recommended protocols can talk many apprehensive patients through the procedure. Also, the increasing use of open MRI units is reducing the number of patients who are anxious and unable to complete scans.

Highly anxious patients and those with extreme claustrophobia can benefit from calming medications. Oral lorazepam (Ativan) is a common premedication for patients who suffer claustrophobia, anxiety, or panic attacks during MRI scans. When medications are needed during the scanning procedure, short acting agents such as intravenous lorazepam, diazepam, alprazolam, and intranasal midazolam are often used. Administration of these drugs is covered

by most institutional sedation guidelines.

## **Follow-up Care**

Care of patients after MRI scans is fairly straightforward and uncomplicated. Patients have no special restrictions after non-contrast scans, and they are free to resume their normal diets and activities.

When intravenous contrast agents are administered during scans, nurses should encourage fluids after the scans and observe patients for delayed adverse reactions. Contrast agents clear rapidly from the body, so nurses usually monitor these patients for an hour or two after their scans. Few adverse reactions to contrast agents have been reported. When IV sedation is used, nurses must assess patients for confusion and respiratory distress.

MRI scans are performed for a variety of clinical conditions. Careful planning, patient preparation, and forethought by nurses helps to make scans easy and safe.

## **Contraindications**

The main consideration for MRI scans is to provide a safe environment for the patients and staff. Patients are reminded that they must remove all metal objects to prevent interactions with the powerful magnet in the scanner. They must remove objects such as wedding rings and other jewelry, watches, and hairpins. Patients and staff should leave credit cards and bank cards outside the scanner suite because the magnetic field might deactivate them. Installation and use of metal detectors to additionally screen patients and staff has also been recommended to insure safety and prevent injuries.

Whether the presence of certain metals creates a relative or absolute contraindication to performing the study is evaluated on a case by case basis. Metal objects can dislodge, heat up as they absorb energy, or malfunction during MRI scans. MRI scans should be done only with a cardiologist's approval during the first four to six weeks after placement of intracoronary stents.

Patient weight and the ability to lie completely still and cooperate during the test also might limit the use of MRI scans. Most scanning units accommodate only patients up to 300 pounds in body weight. Patients must be able to lie completely still for 45 to 60 minutes while scanning is done. Music and prism glasses that enable patients to see out of the MRI unit are used in some scanning centers. Disposable ear plugs or commercially available MRI-compatible head phones can protect patients from the adverse effects of the loud thumping noise occurring during scanning.

MRI scans can be performed with patients in prone or supine positions, depending on anatomic regions examined. The supine position is best for scans of the foot and ankle when the hind and mid foot are examined. The prone position works better for evaluating the forefoot. For either position, the foot should be supported with foam sponges to prevent unintentional movement during the scan.

An intravenous line is inserted when contrast agent is used so it can be administered during the procedure. The reported rate of adverse reactions is 2 to 4%, nurses and staff should always be alert for the possible reactions. Nausea, emesis, hives, and headaches are common systemic reactions. Most reactions are minor and do not warrant medical intervention. Localized reactions can occur around the injection site and symptoms include irritation, focal burning, or cool sensations.

## Scan Interpretation

Interpretation of MRI scans requires in-depth knowledge of the scanned organ system's normal anatomy. Radiologists most commonly interpret MR studies, and they include physicians who are diagnostic radiologists, interventional radiologists, and nuclear medicine physicians. Neuro-radiologists also might review scans of the brain.

Medical professionals who review scans often find that also reviewing other radiographic studies, such as CT or plain x-rays, can be helpful to interpret MRI scans. For example, results of plain x-rays often optimize MRI interpretation of foot and ankle scans.

Interpretation also depends on the type of MRI technique used for the scan. For example, for T1, T2, or FLAIR scans, the relative brightness of structures on T1 and T2 images is compared to determine their composition. Fatty tissue is brighter on T1 compared with T2 images. High water content areas, such as cerebrospinal fluid, appear dark in T1 images, but bright in T2 images. Bone appears black in both types of images because it contains little hydrogen.

Disease states appear in various ways. For example, MRI scans of patients who have Multiple Sclerosis usually demonstrate white matter lesions or plaques in the brain, brain stem, and spinal cord. The state of hydration and morphology of the disc can be visualized in the temporomandibular joint.

MRI scan results are available quickly so radiologists can immediately communicate information about critical abnormalities to attending physicians. For all MRI scans, written reports follow for placement in patient charts and discussion between patients and their health care providers.

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## Course Exam

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1. MRI scans are useful for immediately distinguishing ischemic and hemorrhagic strokes.  
 True  False
2. MRI scans directly create spinal cord images that enable accurate diagnoses of many spinal conditions.  
 True  False
3. Many types of cerebral and vascular MRI scans do not require administration of a contrast agent.

True  False

4. Radio frequency pulses excite the hydrogen atoms and the energy they produce is used to create MRI images.

True  False

5. Magnetic Resonance Angiography (MRA) is currently more accurate than conventional angiography.

True  False

6. The FLAIR technique is useful in brain imaging for multiple sclerosis because it offers improved image contrast between brain tissue and cerebrospinal fluid.

True  False

7. BUN and CR levels should be checked before IV contrast agent is used for MRI scans.

True  False

8. Patient sedation contraindicates MRI scans.

True  False

9. Nurses ask patient about artificial heart valves, hearing aids, eye injuries, and tattooed eyeliner after MRI scans.

True  False

10. The presence of certain metals is evaluated on a case by case basis before MRI scans are contraindicated.

True  False