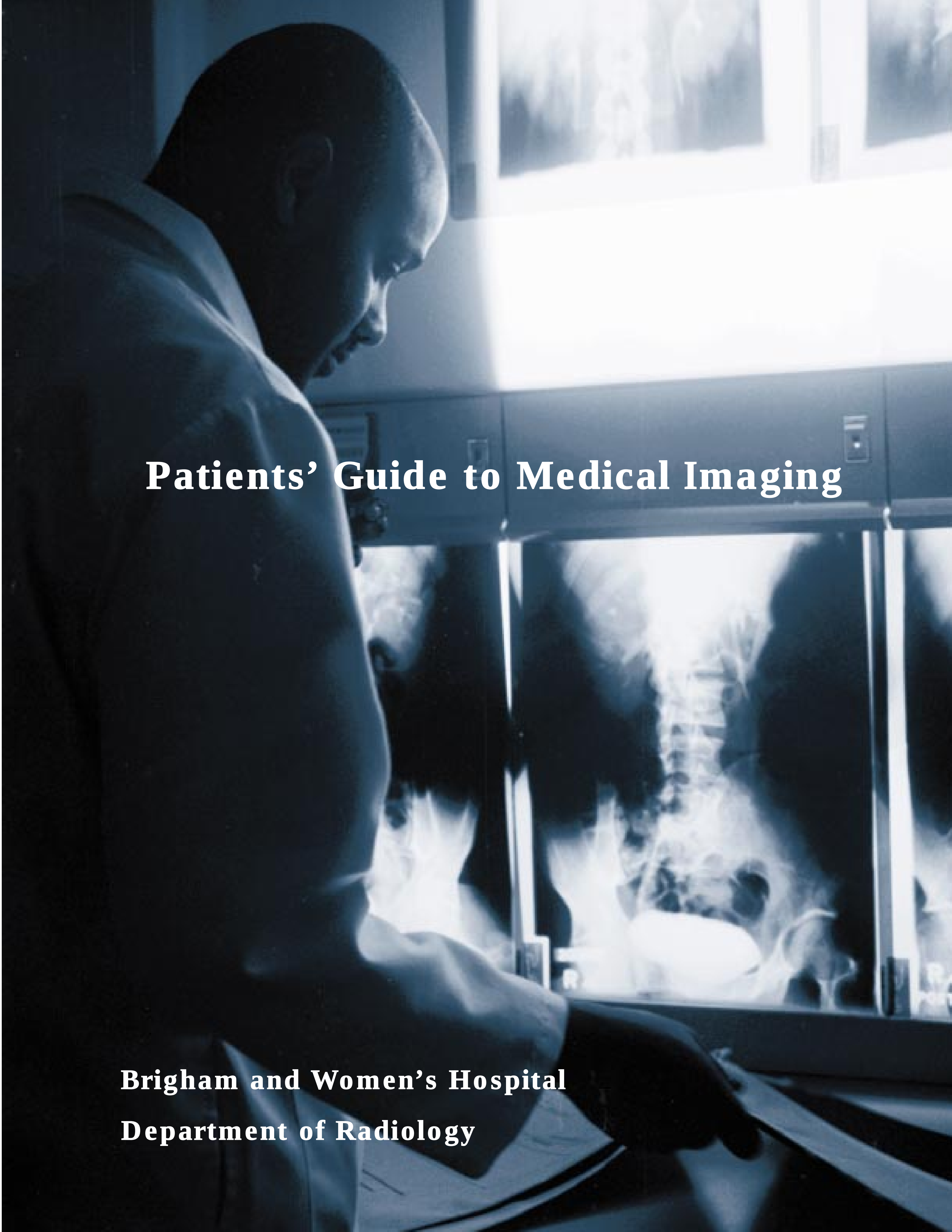
Patients' Guide to Medical Imaging



Brigham and Women's Hospital

Department of Radiology

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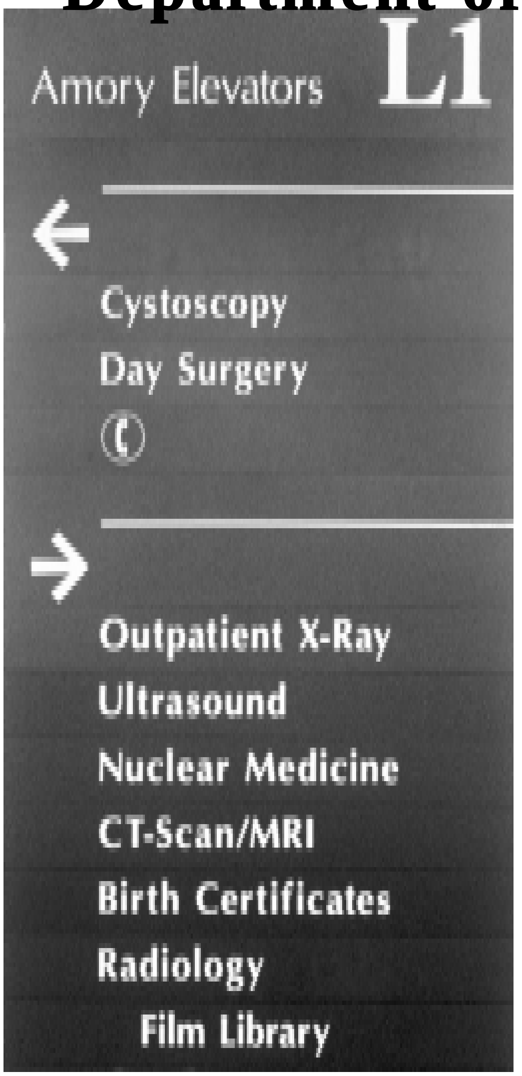

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Welcome to Radiology

We are delighted that you have chosen to have your imaging study at Brigham and Women's Hospital. We have assembled a large number of highly qualified individuals, from postdoctoral fellows to patient escorts and receptionists, to make your visit as comfortable as possible.

Inpatient and outpatient facilities administered by our Department of Radiology are dedicated to basic and clinical research, teaching and training of physicians and others, and most importantly, patient care.

Radiologic examinations offer safe and noninvasive methods of gaining information for improved diagnosis and treatment.

Frequently asked questions include:

"Why do I need so many seemingly repetitious procedures, such as a chest x-ray, EKG, and stress test?"

"Am I receiving too much radiation?"

"Will it hurt?"

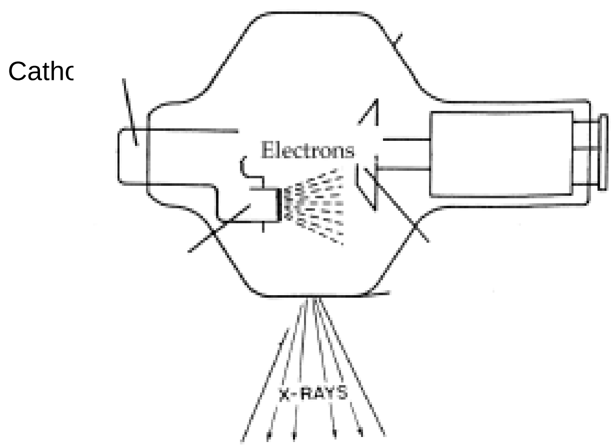
"How long does it take?"

"Must I skip my breakfast and coffee?"

We hope that the following information is helpful in answering most of your questions about medical imaging and in alleviating some of the *unknowns* you may have. Please feel free at all times to discuss any additional questions or concerns with the nurse, technologist, or radiologist.

Diagnostic (plain film) Radiography

Plain film radiography unifies principles of photography, anatomy, and x-ray production. X-rays are produced by applying an electric potential across a tube, where electrons are “boiled off” a cathode filament. This electron stream strikes a rotating, positively charged target, the anode. The spinning sound one can often hear during the x-ray study is the rotation of the anode. When the electrons slow down, and when they strike the target, x-rays are produced. A person cannot feel, taste, or see the x-rays as they pass through the body.



Representation of a working x-ray tube.

The amount and type of x-rays are selected by the operator, usually the radiologic technologist (RT), who adjusts exposure and beam quality. Pre-set ranges are based on the patient thickness, the tissue being imaged, and the desired image contrast. Because motion of the lungs and diaphragm blurs the image—much as when a photographic subject moves during the snap—patients are usually asked to hold their breath during the exposure.

The final product is stored on a piece of film, the radiograph. The radiographs are read by the radiologist, a physician specially trained to interpret the images. The x-ray diagnosis is transcribed into a written report and sent to the requesting physician.

Plain film radiography is safe, noninvasive, and quickly performed. The average exam takes no more than 10-15 minutes per part (e.g., cervical spine, knee, or chest x-ray). For most plain film exams, no special patient preparation is required. The developing embryo is much more sensitive to the effects of ionizing radiation than the adult patient. It is important then to notify the technologist, prior to any x-ray procedure, if there is any possibility that you may be pregnant.

Mammography

Mammography, also a plain-film x-ray technique, is designed for breast examinations. The breast is placed on a film and gently pressed. The compression, although uncomfortable, greatly improves the visibility of abnormalities.

Mammography, as a screening tool, has been found to save many lives. The staff at BWH are specially trained, equipped and licensed in the use of mammography, and the Division is regularly inspected to ensure quality and accuracy in our practices and equipment.

Positioning for mammography at BWH.

Contrast Radiography

"It's alimentary!"

A major improvement to the diagnostic accuracy of radiography has been the addition of contrast agents, which can be administered in a vein or instilled in a duct or hollow organ, such as barium sulfate in the alimentary tract.

A contrast medium contains relatively dense material of a high atomic number that absorbs more of the x-rays than the surrounding tissues, hence making the stomach, colon, or vessel appear white on the x-ray film. One can then look for structural changes such as polyps, stones, or ulcerations.

Upper Gastrointestinal Series (UGI)

Stomach and portions of the small intestine demonstrated with a barium sulfate suspension.

The UGI is an x-ray examination of the esophagus and stomach and is sometimes followed by films of the small bowel. You should arrive with an empty stomach (no food or drink after midnight). The radiologist will ask you to drink a barium mixture, which coats the digestive tract so that it becomes more visible on the film. The radiologist views the movement of barium on a television monitor and may take several films while moving the patient to different positions. Occasionally, patients will also be asked to swallow crystals that will add gas to the UGI tract, helping to delineate the mucosal layers of the stomach. After the radiologist's examination, the technologist will take several more films and may ask the patient to drink more barium. The barium is similar to milk of magnesia in consistency and taste.

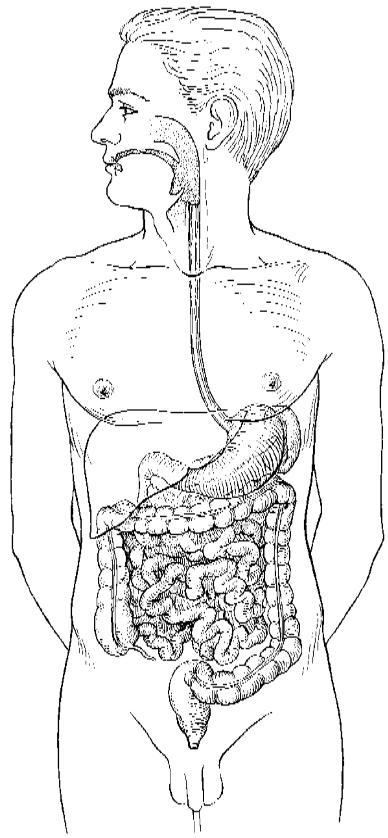
The exam should take approximately one hour. Additional films of the barium moving through the small intestine may be taken when requested by the referring physician. This can add anywhere from 45 minutes to several hours. Throughout these procedures, the patient usually feels no discomfort or pain.

Barium Enema

The lower GI tract, including the colon and rectum, are also important areas to examine. The x-ray procedure for that area is called the *barium enema.*

In addition to not eating breakfast, a bowel-cleansing preparation must be administered the day before the procedure to permit clearer images of the large bowel and surrounding tissues.

At the time of examination, a barium mixture is instilled through an enema tip placed in the rectum by the radiologist. This procedure may cause some discomfort but is not painful. As it is instilled, the radiologist will examine and film the flow of barium. Sometimes, air is added to the barium mixture. The patient will be asked to move to several different positions. Patients should try to relax and hold their breath when instructed so as to avoid blurred radiographs. When the radiologist has completed his or her portion of the exam, a radiologic technologist will take several more films to demonstrate various portions of the large bowel. Once the film sequence is finished, the technologist will assist the patient to the toilet. Afterward one or more films will be taken to demonstrate the emptied bowel.



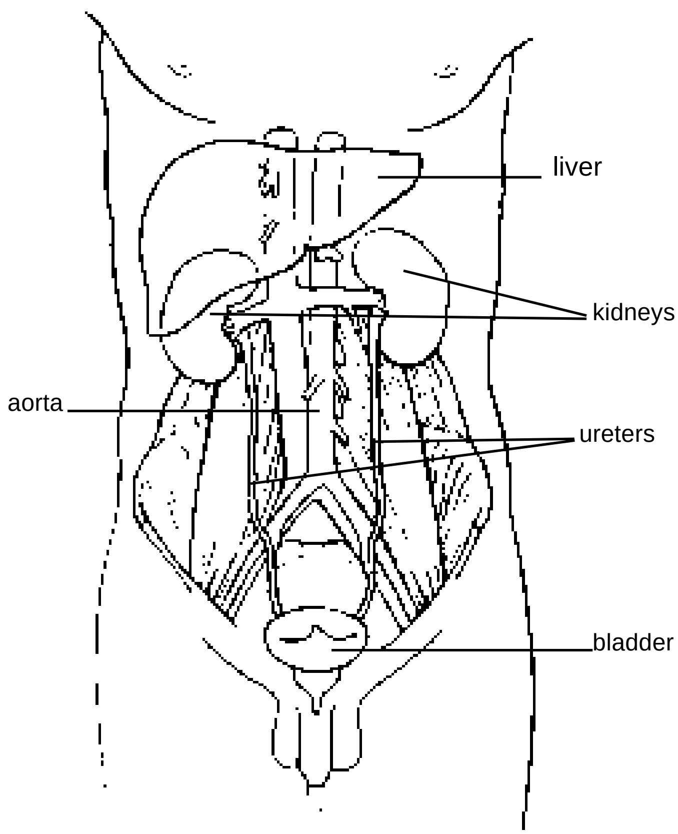
Gastrointestinal tract.

Intravenous Urography

To examine the urinary tract, a contrast medium containing iodine is injected intravenously (into a vein, usually in the arm). The iodine improves the contrast on the x-ray image. Some people are allergic to iodine and must be premedicated. Prior to the procedure, all patients should be sure to fill out the contrast screening form and to notify the technologist of any prior reaction.

Intravenous urography (IVU) and *pyelography* (IVP) are different names for x-ray examination of the kidneys, ureters, and bladder. This test yields information about the function of the kidneys, the presence of stones in the urinary tract, and the passage of urine from the kidneys, ureters, and bladder.

The test takes approximately one hour. Some patients may experience a brief sensation of warmth, nausea, or a metallic taste in the mouth after the contrast medium injection. Other patients may experience itching, hives, or other effects. The technologist or nurse closely monitors all patients for any adverse drug events.



Kidneys, ureters and bladder.

Anteroposterior film at 15 minutes after injection of iodinated contrast demonstrates kidneys, ureters and bladder.

Frequently, a technology known as linear tomography is used during urography. The x-ray tube and film cassette move over part of the body while the exposure takes place. This motion blurs the overlapping tissues and renders a sharp image of the selected tissue plane. Several of these images are taken as well as other films in different positions. Near the end of the exam, the technologist escorts the patient to the toilet to empty the bladder. Once back on the table, a film is taken of the patient's emptied bladder. After the films are checked by the radiologist, the exam is complete.

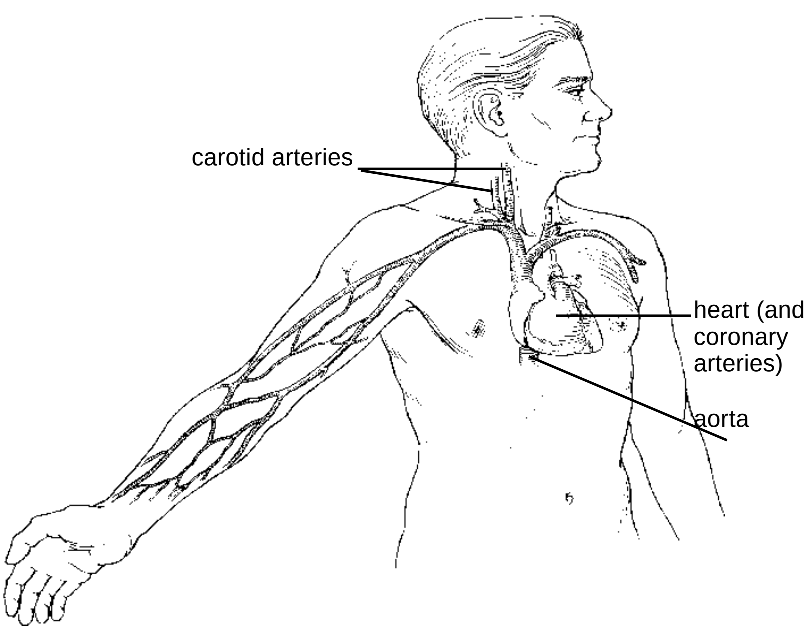
Nephrotomography blurs the structures surrounding the kidneys.

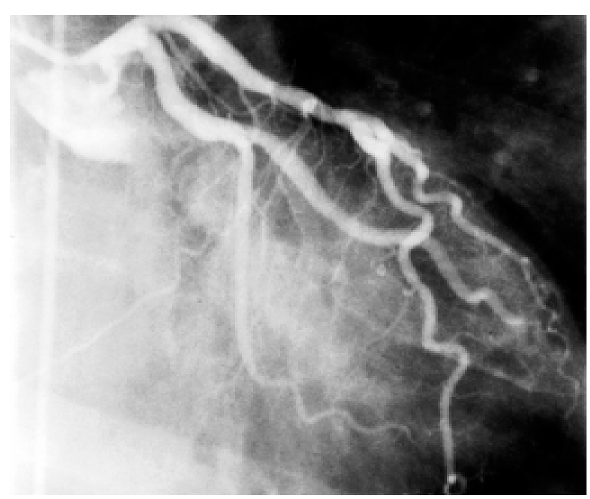
Angiography

Angiographic and interventional radiologic techniques are also performed with injected contrast. In this instance, catheter insertion or needle placement is performed under fluoroscopic guidance, so that a particular vessel or organ can be seen and, in some instances, repaired via the catheter.

A classic example is angioplasty, for which a catheter is threaded into an obstructed vessel. An attached balloon is inflated to increase the opening of the vessel—thus improving blood supply to the tissues. This procedure is commonly performed on vessels in the heart, abdomen, and legs. As one might expect, these interventional techniques are complex procedures, involving teams of nurses, doctors, and technologists working together.

The great advantage is that angioplasty and other image-guided interventional procedures replace the need for (and risks of) surgery and general anesthesia for many patients. The interventional service offers more specific information and advice for patients undergoing these procedures.





Opacification of the coronary arteries.

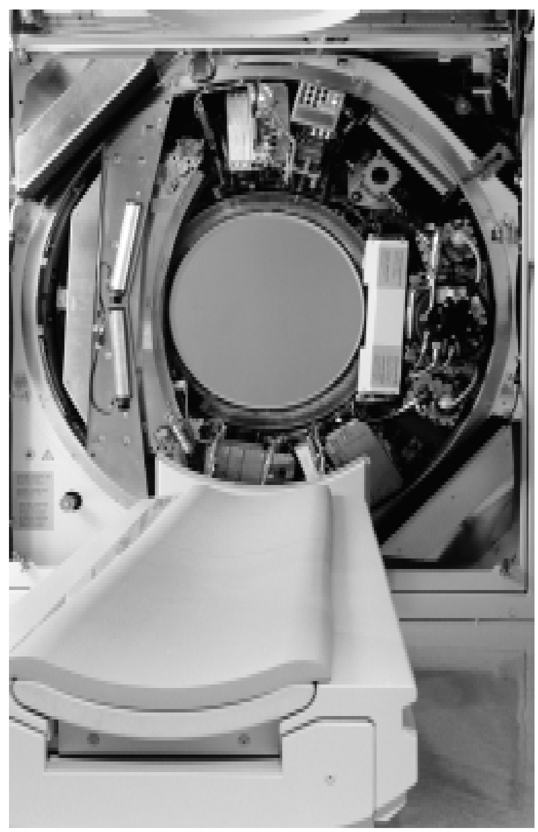
Computed Tomography (CT)

In the mid 1970s, computed axial tomography (CAT) scanners became available, thus revolutionizing medical imaging. Cumbersome, expensive, and time-consuming at first, newer generations of CT scanners permit helical (or spiral) scans of complete organ volumes within seconds. The fast scans allow images during breath-holding, thus minimizing respiratory motion artifacts. This technology can also be applied to the chest, abdomen, pelvis, brain and extremities.

Within the gantry, a row of radiation detectors encircles the patient, while a rotating x-ray beam passes through the patient. The multiple transmitted beams are registered and back-projected, so that a transaxial “slice” of high resolution and contrast can be generated. Newer computational techniques have made it possible to create three-dimensional renderings as well as coronal (front to back) and sagittal (side to side) plane slices.

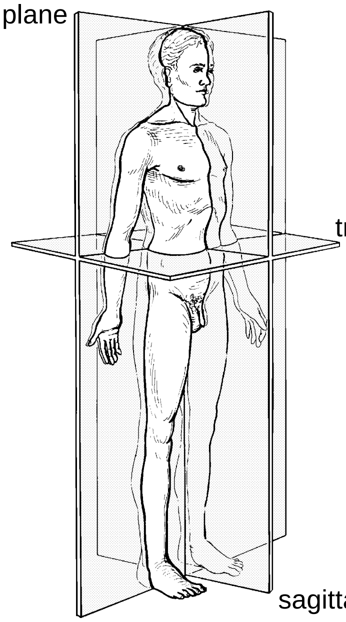
Most CT scans take no longer than 30 minutes although additional time may be needed to set up an intravenous line and adjust positioning. Some patients will be asked to arrive one hour ahead of time so that the barium mixture they drink will reach and outline the gastrointestinal tract. During the exam, the technologist monitors the patient through a leaded window and can answer the patient’s questions via an intercom.

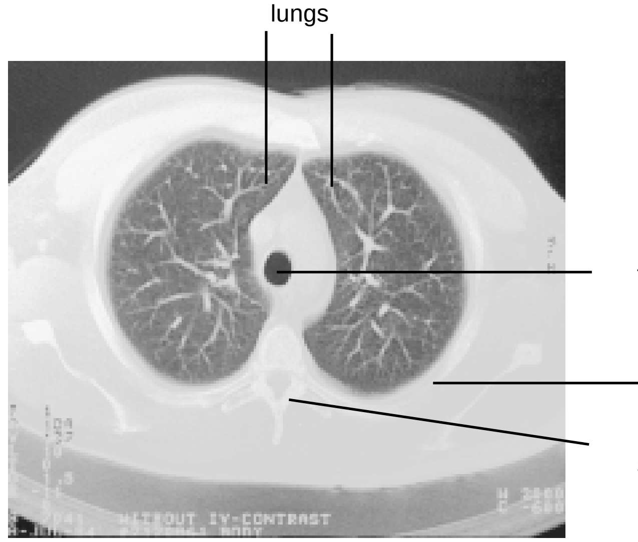
CT suite and monitoring desk with technologist.



Open gantry of CT scanner demonstrating x-ray tube, detector, shielding and circuitry.

Preparing a patient for a CT scan.





Transaxial CT slice through the chest.

Magnetic Resonance Imaging (MRI)

An equally impressive technology, magnetic resonance imaging or MRI, has greatly improved the sensitivity and specificity (accuracy) of diagnostic imaging, particularly in structures such as the liver, brain, spinal cord, and joint spaces.

A great advantage of MRI is that the patient is not exposed to x-rays. The images are created with the use of strong magnetic fields, radiofrequency transducers (commonly called coils), and computer-assisted image processing. To date, no ill health effects have been reported by use of superconducting magnets or radiofrequency pulses in the diagnostic range.

The process can be explained as:

1. Nuclei of the molecules within a human body are randomly aligned magnetically.

2. When we walk into a room with a strong magnetic field, those same molecules align themselves to the magnetic field.

3. For an MRI examination, a coil placed on or around you generates a pulse of energy.

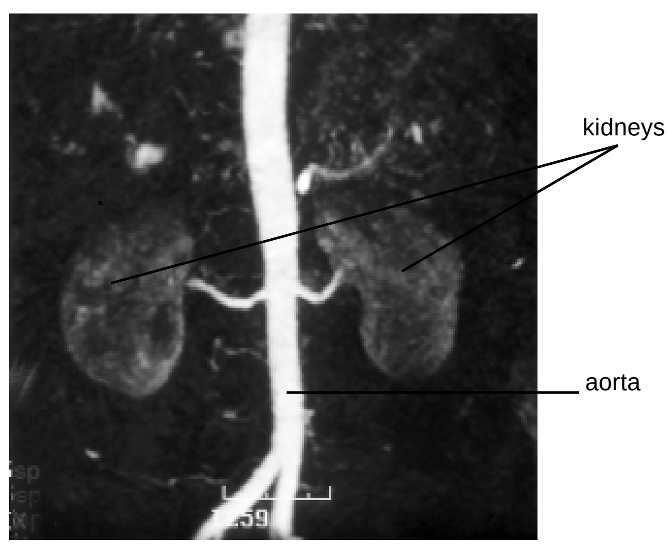
4. The molecules then realign with the pulse of energy.

5. When the pulse is turned off or reapplied, the molecules return to their positions, creating a detectable signal.

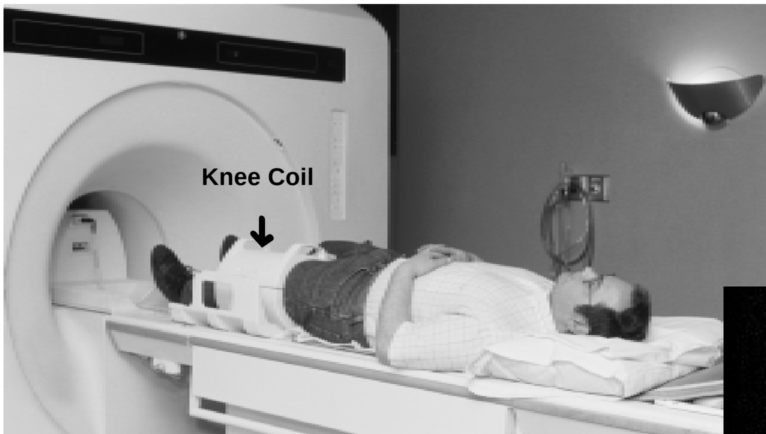
6. These detectable signals are processed by the computer into a series of images.

7. Patients feel no pain during the MRI examination.

Sagittal view of the head from an MR scan.



MR angiogram showing the kidneys and aorta.



The knee coil for MR imaging, shown above, is used to create high resolution images of this joint as shown to the right.

Various pulse frequencies and radiofrequency orientations create differing signals based on tissues' respective amounts of protons. The technologist can then select imaging protocols which optimize the appearance of water, fat, blood, and pathologic processes. By careful time sequencing, the operator can also generate flow images within vessels, the so-called magnetic resonance angiogram (MRA).

Solutions such as gadolinium are sometimes administered intravenously (injected into an arm vein) as contrast agents to enhance lesions. Few adverse drug events are reported with these agents.

Prior to the MR examination, patients are asked to fill out a screening questionnaire to identify any indwelling magnetic materials (metal fragments, shunt regulators, or other devices) that may not be safely placed in the magnetic field. Many devices, despite containing metal, can be safely imaged.

During the examination, which takes an average of thirty minutes, a "knocking" sound can be heard. This is a normal effect of the gradient coils responding to the different fields. Despite this noise, most patients can easily tolerate the procedure. As with the CT scan, a technologist is always in close observation and intercom communication with the patient throughout the procedure.

Investigational offshoots of MRI include MR-assisted therapy, such as biopsies, laser therapy, and high frequency ultrasound ablations. These procedures are performed in operative suites containing open magnet devices, which permit the interventional team to perform procedures on the patient during MR scanning.

Ultrasound

In many instances, a quick and painless exam can be performed without ionizing radiation. The exam is called a sonogram, or ultrasound scan. *Ultrasound* is defined as sound with a frequency greater than 20,000 cycles/sec (Hertz, or Hz), which is the upper limit of audible sound. Sonography for diagnostic imaging purposes employs frequencies of one million to twenty million cycles per second. These are produced by a device known as a transducer, which is placed directly on, and occasionally within, the patient. The device contains a material that vibrates upon receiving a voltage charge. Sound waves are then created and either transmitted, refracted, or reflected back to a receiver. The degree of reflection is based on applied frequency, the sound velocity, and the acoustic impedance of the tissue. In other words, different tissues will have different responses to the sound waves.

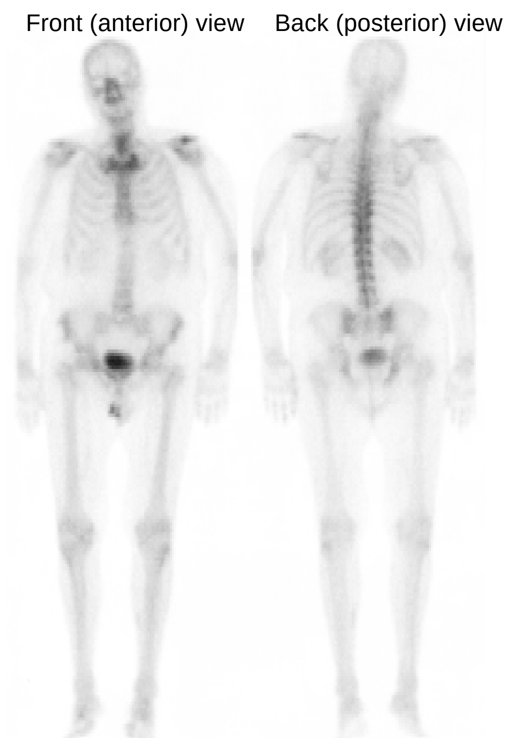
Prenatal sonogram assists in estimation of gestational age.

Various transducers have been optimized for specific body parts. Major applications of ultrasound include obstetrical imaging, abdominal imaging, and Doppler imaging, a variant technique used in heart and vascular diagnosis. In some instances, biopsies are performed under the guidance of ultrasound, permitting more accurate and less invasive tissue sampling.

Nuclear Medicine

Characterization of tissues beyond structural changes, or more accurately stated, *before structural changes*, has been a goal of numerous medical scientists. Although improvements are needed in specificity, and in anatomic resolution, the examinations performed in nuclear medicine do offer many measurements of biochemistry or tissue function. As some have stated, what we call structures are slow processes of long duration. What we call functions are fast processes of short duration. Structure and function are two views of a unitary process. Nuclear medicine imaging, also called *scintigraphy* or *radionuclide imaging,* offers information about many of those processes.

The imaging machines, known as *gamma cameras,* do not emit radiation but serve as detectors that sample the trace amounts of radioactivity introduced into the patient, often by intravenous injection. (One can think of the camera as an array of sophisticated Geiger counters.) Many patients, quite naturally, are concerned about having radioactive materials injected into them. You should not worry. Nuclear medicine facilities around the world (including Brigham and Women's Hospital) follow safe practices and inject only a safe and carefully measured quantity of radiation. Additional good news is that the materials do not stay in the body. Most are eliminated or naturally decay within several hours or a few days.



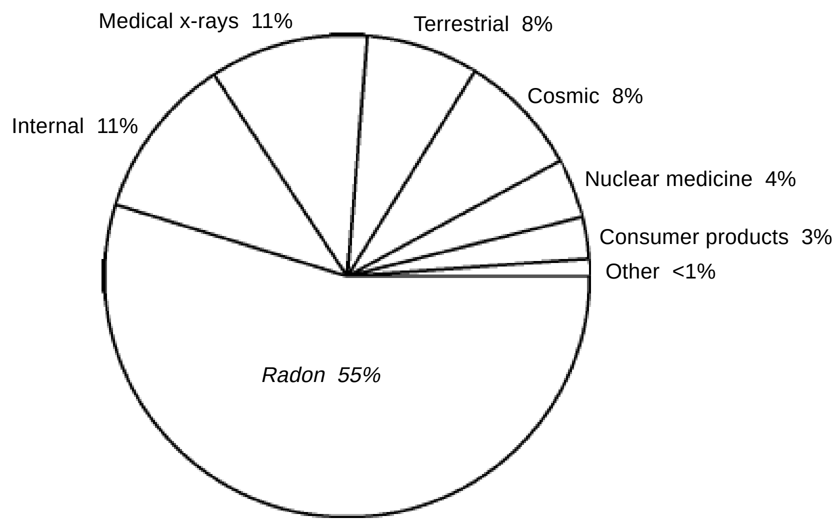
Planar bone scan in an adult shows the normal distribution of radionuclide.

The images can be planar maps of distribution, such as in a bone scan, or, as in CT, cross-sectional images can be derived from a process known as emission computed tomography. The two principal types are single photon emission computed tomography (SPECT) and positron emission tomography (PET). PET's advantages include high-resolution images and the ability to image radiolabeled active biologic compounds such as oxygen, nitrogen, carbon, and water.

The nuclear medicine exams are noninvasive and take 30 minutes to several hours. Some typical exams are the bone scan, the gallium scan, and the stress myocardial exam, also known as the ETT. Few of these exams require special patient preparations.

Concluding Statements

Medical imaging procedures make up only a small portion (15%) of total radiation exposure to most Americans.



The percentage contribution of various radiation sources to the average effective dose of various radiation sources to the average effective dose equivalent in the US population. Taken with permission from Report No. 93, National Commission on Radiation Protection and Measurements (1987).

Because they work with radiation sources on a daily basis, radiation workers (the technologists and radiologists) work behind lead shields or aprons. This does not mean that the exam room is unsafe for the patient. All of the Radiology staff adhere to the *ALARA* concept, which means to limit the radiation exposure to *A*s *L*ow *A*s *R*easonably *A*chievable. Lead shields, proper technique selection, limitation of the beam, and reduced radiopharmaceutical dosages for pregnant and nursing patients are the means by which we reach the ALARA goals. Specific dose information, on a case-by-case basis, can be calculated if necessary.

The literature shows that various types of medical images may be complementary rather than exclusive of one another. In other words, each examination shows different elements of the body's state—structural changes such as a fracture, metabolic changes, or normal changes associated with aging. Therefore, as a patient, you may be here for several different exams in the same day or week. Your physician will put all of the information together with laboratory results and physical examination to complete the picture.

From time to time, emergency add-on cases, extremely ill patients, and the occasional equipment malfunction will delay your imaging procedure. We apologize for such events and make every effort to minimize delays. We appreciate the opportunity to assist in your diagnosis and care and look forward to being of service to you.

Helpful telephone numbers

BWH Radiology Scheduling Office	(617) 732-6248
BWH Ambulatory Radiology Reception	(617) 732-6257
BWH Radiology Film Library	(617) 732-7818
BWH Cardiovascular and Diagnostic Interventional Center (previously called Angiography)	(617) 732-7240
BWH Radiology CT/MRI Reception	(617) 732-7970
BWH Radiology Inpatient Reception	(617) 732-7185
BWH Radiology 850 Boylston Reception	(617) 278-0560
BWH Radiology Mammography Reception	(617) 732-8525
BWH Radiology Nuclear Medicine Reception	(617) 732-6215
BWH Radiology Ultrasound Reception	(617) 732-7189

BWH Radiology on the World Wide Web

You may also wish to visit our website, BrighamRAD, which contains online brochures, virtual tours, and other educational materials. The site can be accessed at:

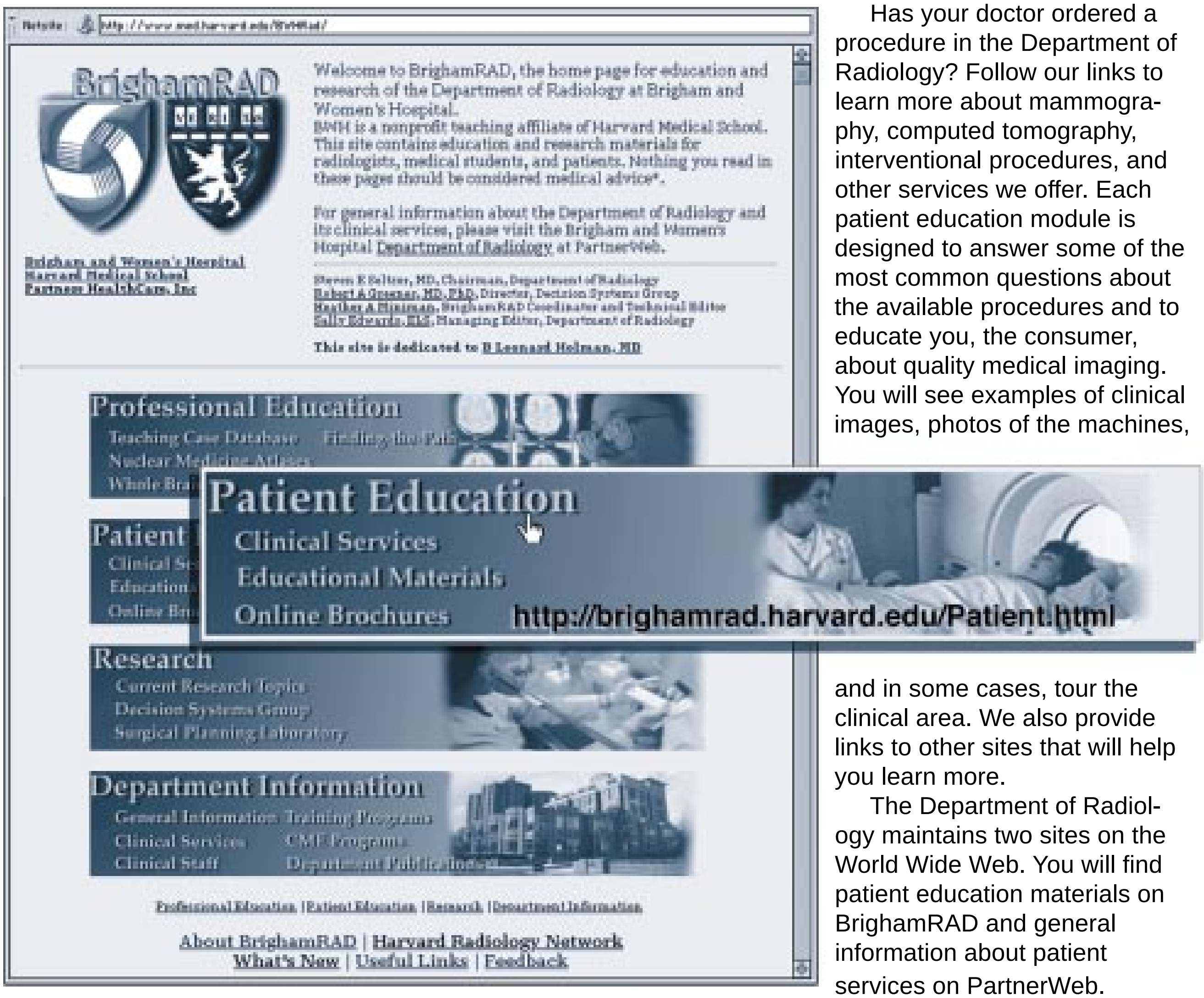
http://brighamrad.harvard.edu

General information about our staff and patient services is available on the Partners HealthCare website:

http://www.bwh.partners.org/radiology

BrighamRAD

Quality Medical Information on the Internet



Has your doctor ordered a procedure in the Department of Radiology? Follow our links to learn more about mammography, computed tomography, interventional procedures, and other services we offer. Each patient education module is designed to answer some of the most common questions about the available procedures and to educate you, the consumer, about quality medical imaging. You will see examples of clinical images, photos of the machines, and in some cases, tour the clinical area. We also provide links to other sites that will help you learn more.

The Department of Radiology maintains two sites on the World Wide Web. You will find patient education materials on BrighamRAD and general information about patient services on PartnerWeb.

Visit the Brigham and Women's Hospital Department of Radiology on line.

BrighamRAD: http://brighamrad.harvard.edu
PartnerWeb: http://www.bwh.partners.org/radiology

Cover photograph: Yasir Abdelbasit, RT, reviews films for quality and completeness of imaging technique. *(K Mancini)*