What are x-rays and what do they do?

X-rays are forms of radiant energy, like light or radio waves. Unlike light, x-rays can penetrate the body, which allows a radiologist to produce pictures of internal structures. The radiologist can view these on photographic film or on a TV or computer monitor.

X-ray examinations provide valuable information about your health and play an important role in helping your doctor make an accurate diagnosis. In some cases x-rays are used to assist with the placement of tubes or other devices in the body or with other therapeutic procedures.

Measuring radiation dosage

The scientific unit of measurement for radiation dose, commonly referred to as effective dose, is the millisievert (mSv). Other radiation dose measurement units include rad, rem, roentgen, sievert, and gray.

Because different tissues and organs have varying sensitivity to radiation exposure, the actual radiation risk to different parts of the body from an x-ray procedure varies. The term effective dose is used when referring to the radiation risk averaged over the entire body.

The effective dose accounts for the relative sensitivities of the different tissues exposed. More importantly, it allows for quantification of risk and comparison to more familiar sources of exposure that range from natural background radiation to radiographic medical procedures.

Naturally-occurring "background" radiation exposure

We are exposed to radiation from natural sources all the time. According to recent estimates, the average person in the U.S. receives an effective dose of about 3 mSv per year from naturally occurring radioactive materials and cosmic radiation from outer space. These natural "background" doses vary throughout the country.

People living in the plateaus of Colorado or New Mexico receive about 1.5 mSv more per year than those living near sea level. The added dose from cosmic rays during a coast-to-coast round trip flight in a commercial airplane is about 0.03 mSv. Altitude plays a big role, but the largest source of background radiation comes from radon gas in our homes (about 2 mSv per year). Like other sources of background radiation, exposure to radon varies widely from one part of the country to another.

To explain it in simple terms, we can compare the radiation exposure from one chest x-ray as equivalent to the amount of radiation exposure one experiences from our natural surroundings in 10 days.

Following are comparisons of effective radiation dose with background radiation exposure for several radiological procedures described within this website:

For this procedure:	* Your approximate effective radiation dose is:	Comparable to natural background radiation for:	** Additional lifetime risk of fatal cancer from examination:
ABDOMINAL REGION:			
Computed Tomography (CT)-Abdomen and Pelvis	10 mSv	3 years	Low
Computed Tomography (CT)-Abdomen and Pelvis, repeated with and without contrast material	20 mSv	7 years	Moderate
Computed Tomography (CT)-Colonography	10 mSv	3 years	Low
Intravenous Pyelogram (IVP)	3 mSv	1 year	Low
Radiography (X-ray)-Lower GI Tract	8 mSv	3 years	Low
Radiography (X-ray)-Upper GI Tract	6 mSv	2 years	Low
BONE:			
Radiography (X-ray)-Spine	1.5 mSv	6 months	Very Low
Radiography (X-ray)-Extremity	0.001 mSv	3 hours	Negligible
CENTRAL NERVOUS SYSTEM:			
Computed Tomography (CT)-Head	2 mSv	8 months	Very Low
Computed Tomography (CT)-Head, repeated with and without	4 mSv	16 months	Low

contrast material			
Computed Tomography (CT)-Spine	6 mSv	2 years	Low
CHEST:			
Computed Tomography (CT)-Chest	7 mSv	2 years	Low
Computed Tomography (CT)-Chest Low Dose	1.5 mSv	6 months	Very Low
Radiography-Chest	0.1 mSv	10 days	Minimal
DENTAL:			
Intraoral X-ray	0.005 mSv	1 day	Negligible
HEART:			
Coronary Computed Tomography Angiography (CTA)	12 mSv	4 years	Low
Cardiac CT for Calcium Scoring	3 mSv	1 year	Low
MEN'S IMAGING:			
Bone Densitometry (DEXA)	0.001 mSv	3 hours	Negligible
NUCLEAR MEDICINE:			
Positron Emission Tomography – Computed Tomography (PET/CT)	25 mSv	8 years	Moderate
WOMEN'S IMAGING:			
Bone Densitometry (DEXA)	0.001 mSv	3 hours	Negligible
Mammography	0.4 mSv	7 weeks	Very Low
Note for pediatric patients: Pediatric patients vary in size. Doses given to pediatric			

patients will vary significantly from those given to adults.

* The effective doses are typical values for an average-sized adult. The actual dose can vary substantially, depending on a person's size as well as on differences in imaging practices.

**** Legend:**

Risk Level	Approximate additional risk of fatal cancer for an adult from examination:
Negligible:	less than 1 in 1,000,000
Minimal:	1 in 1,000,000 to 1 in 100,000
Very Low:	1 in 100,000 to 1 in 10,000
Low:	1 in 10,000 to 1 in 1000
Moderate:	1 in 1000 to 1 in 500
Note: These risk levels represent very small additions to the 1 in 5 chance we all have of dying from cancer.	

Please note that the above chart attempts to simplify a highly complex topic for patients' informational use. The effective dose listed above may be used to estimate cancer and cancer related deaths.

The International Commission on Radiological Protection (ICRP) Report 103 states: "The use of effective dose for assessing the exposure of patients has severe limitations that must be considered when quantifying medical exposure", and "The assessment and interpretation of effective dose from medical exposure of patients is very problematic when organs and tissues receive only partial exposure or a very heterogeneous exposure which is the case especially with x-ray diagnostics."

If you are interested in researching the use of effective dose further, following are a few resources:

X-ray safety

As with other medical procedures, x-rays are safe when used with care. Radiologists and x-ray technologists have been trained to use the minimum amount of radiation necessary to obtain the needed results. Properly conducted imaging carries minimal risks and should be performed when clinically indicated. The amount of radiation used in most examinations is very small and the benefits greatly outweigh the risk of harm.

X-rays are produced only when a switch is momentarily turned on. As with visible light, no radiation remains after the switch is turned off.

X-rays over your lifetime

The decision to have an x-ray exam is a medical one, based on the likelihood of benefit from the exam and the potential risk from radiation. For low dose examinations, usually those that involve only films taken by a technologist, this is generally an easy decision. For higher dose exams such as computed tomography (CT) scans and those involving the use of contrast materials (dyes) such as barium or iodine, the radiologist may want to consider your past history of exposure to x-rays. If you have had frequent x-ray exams and change healthcare providers, it is a good idea to keep a record of your x-ray history for yourself. This can help your doctor make an informed decision. It is also very important to tell your doctor if you are pregnant before having an exam that involves the abdomen or pelvic region.

Recently there have been a number of studies* linking current or future cancers to previous x-ray imaging studies, especially CT scans. These studies have important limitations in that they lack key data, including: direct radiation exposure measurements for each patient; why the patient underwent the study; and what beneficial information was derived from the CT scan. In addition, underlying statistical models can be fraught with tremendous levels of uncertainty. Nevertheless, these studies are valuable as they highlight the importance of optimizing CT scan techniques and have led to advancements that are resulting in much lower radiation exposures for similar CT studies.

*References:

1. Pearce MS, Salotti JA, Little MP, et al., Radiation exposure from CT scans in childhood and subsequent risk of leukaemia and brain tumours: a retrospective cohort study. Lancet. 2012; 380: 499–505.
2. Mathews JD, Forsythe AV, Bardy Z, et al., Cancer risk in 680 000 people exposed to computed tomography scans in childhood or adolescence: data linkage study of 11 million Australians. BMJ 2013; 346:f2360.
3. Huang WY, Muo CH, Lin CY, et al., Paediatric head CT scan and subsequent risk of malignancy and benign brain tumour: A nation-wide population-based cohort study. British Journal of Cancer (2014), 1–7 | doi: 10.1038/bjc.2014.103.

Pregnancy and x-rays

As with any aspect of medical care, knowing that a patient is or could be pregnant is important information. Pregnancy, for example, might explain certain symptoms or medical findings. When a pregnant patient is ill or injured, the physician will carefully select medications to avoid potential risks to the developing child. This is also true of x-rays.

While the vast majority of medical x-rays do not pose a critical risk to a developing child, there may be a small likelihood of causing a serious illness or other complication. The actual risk depends on how far along the pregnancy is and on the

type of x-ray. Ultrasound studies, for example, don't use x-rays and have never demonstrated any potential risk to pregnancy. X-ray studies of the head, arms, legs and chest do not usually expose the baby directly to x-rays and typically the technologist who takes the x-rays will implement special precautions to ensure that the baby of a pregnant patient is not directly exposed.

Sometimes patients need examinations of the abdomen or pelvis while they are pregnant. When studies of the abdomen or pelvis are required, the physician may prefer to order a different type of exam for a pregnant patient or reduce the number of x-rays from that which is normally acquired. Therefore, it is important that you inform your physician or the x-ray technologist about your reproductive status before the x-ray study is performed.

Most standard x-ray examinations of the abdomen are not likely to pose a serious risk to the child. Some abdominal and pelvic studies such as CT deliver greater amounts of radiation to a developing pregnancy. Informing the radiologist that you are or might be pregnant is important so that your medical care can be planned with both you and your baby in mind. Remember, this is done to optimize medical care by reducing any potential risk.

Radionuclide exams, also known as nuclear medicine, use an x-ray-like radiation. The method of use, however, is quite different from x-rays and produces very different looking images. The same advice for informing your physician or the nuclear medicine technologist about any possible pregnancy before the examination begins is important.

However, in nuclear medicine another precaution is advised for women who are breast-feeding a child. Some of the pharmaceuticals that are used for the study can pass into the mother's milk and subsequently the child will consume them. To avoid this possibility, it is important that a nursing mother inform her physician and the nuclear medicine technologist about this before the examination begins.

Radiation dose from interventional radiology procedures

Interventional radiologic procedures use diagnostic-type imaging equipment to assist a physician in the treatment of a patient's condition. These procedures frequently provide favorable medical results with minimal recovery time. In some cases these procedures avoid the need for conventional surgery or improve the prospects for a favorable outcome from surgery. As with any medical procedure, there are associated risks and the nature of these risks depend on the procedure.

With interventional radiology procedures using x-rays, the level of risk depends on the type of procedure because some use very little radiation, while complex procedures use much more. In general, the risk of developing a cancer from the exposure is not a major concern when compared to the benefits of the procedure. Many of the complex procedures, such as ones used to open a partially blocked blood vessel, repair a weak

area of a bulging vessel, or to redirect blood flow through malformed vessels, use extensive radiation. But such complex procedures are also frequently lifesaving in their benefit and the risks associated with the radiation are of secondary consideration. In very rare cases, some patients develop skin damage as a result of the procedure. As with any surgical procedure, these rare events are important possibilities to consider when procedures are difficult and extensive. Since the risk for such complications depends on the individual circumstances, the physician should discuss these possibilities with the patient as is appropriate.

Ultrasound imaging is sometimes used for interventional radiology procedures. Ultrasound uses acoustic radiation and, at current intensities, no risk is known to exist for this type of imaging procedure. Magnetic resonance imaging is used for other interventional radiology procedures. For these procedures, a careful screening is performed prior to admission to the scanner room. This screening is to make sure that you have not had previous medical or cosmetic procedures that might make the procedure hazardous.

Safety in nuclear medicine procedures

Nuclear medicine is a branch of medical imaging that uses small amounts of radioactive material to diagnose and determine the severity of or treat a variety of diseases, including many types of cancers, heart disease and certain other abnormalities within the body.

Depending on the type of nuclear medicine exam, the radioactive material, or radiotracer, may be injected into a vein, swallowed or inhaled as a gas. The radiotracer will accumulate in the organ or area of the body being examined, where it gives off energy in the form of gamma rays, allowing the radiologist or nuclear medicine physician to view structural and functional information about organs or tissues within the body.

During nuclear medicine exams, patients are exposed to some radiation from the radiotracer and may be exposed to additional radiation, depending on the imaging method used during the procedure. Though the exact amount of radiation exposure can vary, based on the patient's physical dimensions and the part of the body being examined, radiologists and nuclear medicine physicians will use the lowest dose possible in order to obtain the highest quality images.

Nuclear imaging exams can be performed safely on children and pregnant women as long as the benefits outweigh the small associated radiation risk. When performing such exams, careful evaluation should be done to ensure proper/optimal dosage is given. Women should always inform their physician or technologist if there is any possibility that they are pregnant or if they are breastfeeding.

Available from url: http://www.radiologyinfo.org/en/safety/?pg=sfty_xray