Patient Safety-Xray:

Radiation Exposure in X-ray and CT Examinations

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. 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:
Abdominal region:		
Computed Tomography (CT)-Abdomen and Pelvis	10 mSv	3 years
Computed Tomography (CT)-Body	2-10 mSv	8 months to 3 years
Computed Tomography (CT)-Colonography	10 mSv	3 years
Intravenous Pyelogram (IVP)	3 mSv	1 year
Radiography (X-ray)-Lower GI Tract	8 mSv	3 years
Radiography (X-ray)-Upper GI Tract	6 mSv	2 years
Bone:		
Radiography (X-ray)-Spine	1.5 mSv	6 months
Radiography (X-ray)-Extremity	0.001 mSv	Less than 1 day
Central Nervous system:		
Computed Tomography (CT)-Head	2 mSv	8 months
Computed Tomography (CT)-Spine	6 mSv	2 years
Myelography	4 mSv	16 months
Chest:		
Computed Tomography (CT)-Chest	7 mSv	2 years
Computed Tomography (CT)-Chest Low Dose	1.5 mSv	6 months

Radiography-Chest	0.1 mSv	10 days
Children's imaging:		
Voiding Cystourethrogram	5-10 yr. old: 1.6 mSv	6 months
	Infant: 0.8 mSv	3 months
Face and neck:		
Computed Tomography (CT)-Sinuses	0.6 mSv	2 months
Heart:		
Cardiac CT for Calcium Scoring	2 mSv	8 months
Men's Imaging:		
Bone Densitometry (DEXA)	0.001 mSv	Less than 1 day
Women's Imaging:		
Bone Densitometry (DEXA)	0.001 mSv	Less than 1 day
Galactography	0.7 mSv	3 months
Hysterosalpingography	1 mSv	4 months
Mammography	0.7 mSv	3 months

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.

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 are 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.

Manufacturers of intravenous contrast indicate mothers should not breast feed 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 breast-feeding after receiving intravenous contrast. The Manual on Contrast Media from the ACR 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 breast-feeding 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 breast-feeding

after receiving a gadolinium contrast medium. If the mother so desires, she may abstain from breast-feeding 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. You may find it hereon the ACR website.

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.

Additional Information and Resources

The Alliance for Radiation Safety in Pediatric Imaging's "Image Gently" Campaign:

www.pedrad.org/associations/5364/ig/index.cfm?page=388