Towards appropriate use of diagnostic imaging: A guide for medical practitioners and their patients

This resource card aims to provide information and support to patients and general practitioners when discussing diagnostic imaging tests. Ideally, this discussion should be informed by and consistent with the appropriate clinical practice guidelines. This card has been developed by the Medical Radiation Working Group, Cancer Council WA.

INFORMATION FOR PATIENTS

What is diagnostic imaging?

Diagnostic imaging consists of a range of methods that involve taking pictures of a patient's body in order to help reveal injury or disease. From these pictures the doctor gains information to assist diagnosis and make decisions about treatment and care.

Diagnostic imaging methods include: ultrasound, magnetic resonance imaging (MRI), radiography (x-ray), nuclear medicine (use of radioactive isotopes), computerised x-ray tomography (CT scan) and positron emission tomography (PET). Some of these investigations expose patients to low level ionising radiation which can potentially damage them. **However, when the investigation is carefully chosen, the benefit from the information obtained greatly outweighs any risk involved.**

What is ionising radiation?

Radiation consists of many types of rays. Light and heat come from the sun, electric lamps and radiators (heaters). Other types of radiation (eg x-rays) are energetic enough when absorbed by the body to cause chemical reactions in its cells. This radiation is referred to as 'ionising radiation' and the resulting effects can lead to DNA damage and cancer. Everyone is exposed to ionising radiation every day from the sun, outer space, rocks and soil on Earth. This radiation is increased during travel in a plane or during x-ray examination. At present, medical use and the environment contribute about equally to average population exposure.[1,2]

The dose of x-rays we receive, in energy per kilogram, can be measured in units called milliSieverts (mSv). We absorb around 1.5 mSv from the environment every year, this varies in different locations. High-dose radiation is considered to be exposure of 200 mSv or more. The amount of background radiation we are exposed to is in the low-dose range.[1]

The US Department of Health and Human Services produces a list of known or reasonably anticipated human carcinogens (cancer causing agents) called the Report on Carcinogens (RoC). X-rays are classified as a known human carcinogen in the RoC.[3] They have associated low dose x-ray exposure (100-200 mSv) with thyroid, breast and lung cancer and leukaemia, though occurrences are rare.

The International Agency for Cancer Research (IARC), an agency of the World Health Organization, classifies x-rays as carcinogenic to humans.[4]

When people are exposed to radiation through diagnostic imaging, its use must be justified by ensuring that it does more good than harm. **When radiological investigations are done for a specific problem, the potential benefit *significantly* outweighs the very small risk. However, if there is no valid clinical reason for a procedure, the risk is still present for no benefit.**

What are the effects of ionising radiation on your body?

At high doses (avoided in diagnostic imaging procedures), ionising radiation can cause cell death, organ damage and possibly death to the individual. At low doses (less than 100 mSv) the situation is more complex.[5] Low dose radiation effects are believed to be cumulative and increase the risk of getting cancer later in life.[6]

The body is made up of different cells. For example there are brain cells, muscle cells, blood cells, and so on. It is the genetic material within a cell that determines how a cell functions. If damage occurs to this genetic material then it is possible for a cancer to occur. This means the cell has lost the ability to control the rate at which it grows and divides.[5] This is the only known effect of low doses of radiation, and although the risk of this damage is low, it is sensible to reduce exposure to ionising radiation as much as possible.

During childhood growth and development, rapid cell division occurs. This means that the developing foetus and children are more sensitive to radiation exposure than adults. A dose to the foetus of 100–500 mSv can cause developmental problems.[7]

What is your risk of cancer?

In Australia, the risk of developing any cancer before the age of 85 is 1 in 2 for men, and 1 in 3 for women.[8] Of the 114,137 cancers diagnosed in 2009, a small number may have been caused by radiation exposure.[8] However this must be balanced against the clinical benefit that diagnostic radiation can offer.

The risk of cancer from 10 mSv of radiation exposure is believed to be equivalent to half of the risk of being killed on Western Australian roads in the next 10 years.[9]

References

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Cancer Council Western Australia

DIAGNOSTIC IMAGING TESTS

Nuclear medicine

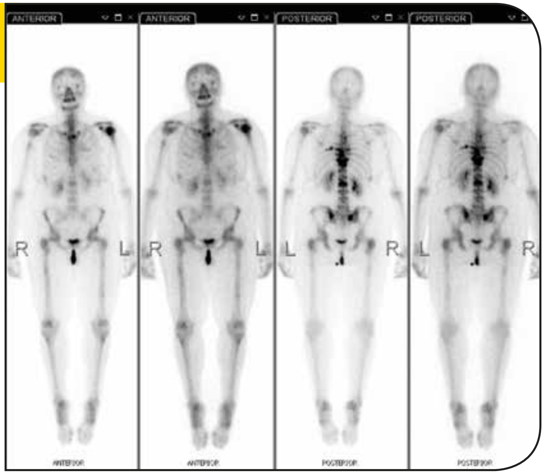
Generally doses of ionising radiation in excess of 5 mSv

Nuclear medicine scans use very small amounts of radioactive material (called radiopharmaceuticals or radiotracers) to diagnose disease and other abnormalities within the body.

Nuclear medicine imaging procedures are usually painless medical investigations. Depending on the type of examination, radioactive material is injected, swallowed or inhaled by the patient. The material collects in the part of the body being examined, giving off radiation in the form of gamma rays (similar to x-rays).

This radiation is detected by a device called a gamma camera which uses a computer to measure the amount of radioactive material absorbed. Pictures are produced which indicate both the structure and function of the body part being studied.

The image on the right is the result of a whole-body nuclear medicine bone scan. Images show many abnormal areas of increased radiotracer activity in the pelvis, spine, ribs, and left scapula. These images are consistent with cancer that has spread to the bones.



Positron Emission Tomography (PET)

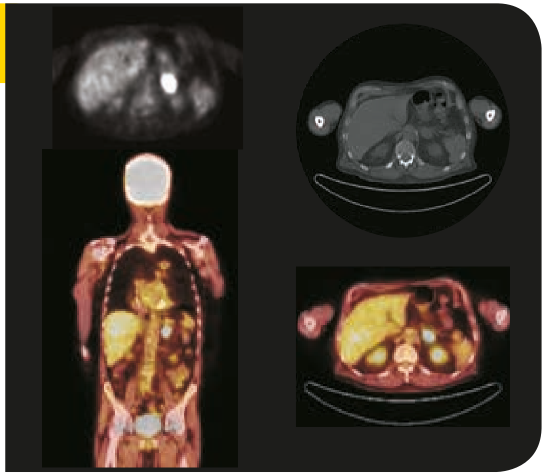
Generally doses of ionising radiation in excess of 5 mSv

Positron emission tomography (PET) provides unique information about how an organ or system in the body is working. PET scans are mainly used to assess cancers, and for brain and heart-related disease.

A PET scan involves the injection of a small amount of a radioactive material (called a radiopharmaceutical). Images of the body are then taken using a PET scanner. The camera detects emissions coming from the injected radiopharmaceutical and the computer attached to the camera creates two- and three-dimensional images of the area being examined.

Areas that are more metabolically active (for example, fast-growing cancer cells) take up more of the injected substance and appear ‘brighter’ than normal tissues on the images.

The image on the right is the result of a PET scan of the abdomen.



Computerised Tomography (CT)

Generally doses of ionising radiation in excess of 5 mSv*

A computerised tomography (CT) scan uses x-rays and computer technology to create detailed two- or three-dimensional images. Unlike other forms of medical imaging, the CT scan can ‘photograph’ every type of body structure at once including bone, blood vessels and soft tissue.

The equipment consists of a large machine with a cylindrical hole through which a reclining patient can be passed. An x-ray source and detectors then rotate around the patient to make recordings which are processed by computer to provide a series of cross-sectional pictures of the body.

The image on the right is from a CT scan of the abdomen, specifically looking for an abnormality in the liver.

* Note that some modern scanners may have lower doses.

X-ray (other than Computerised Tomography CT)

Generally doses of ionising radiation less than 5mSv

An x-ray examination is used to create pictures of the internal organs or bones to help diagnose conditions or diseases. An x-ray machine emits a relatively small amount of ionising radiation. This radiation passes through the body and is recorded on an image receptor to produce the picture.

The calcium in bones blocks the passage of radiation, so healthy bones show up as white or grey. By contrast, radiation passes easily through air spaces, so healthy lungs appear black. Mammograms are x-rays of the breast.

The picture on the right is an x-ray of the chest.

Magnetic resonance imaging (MRI)*

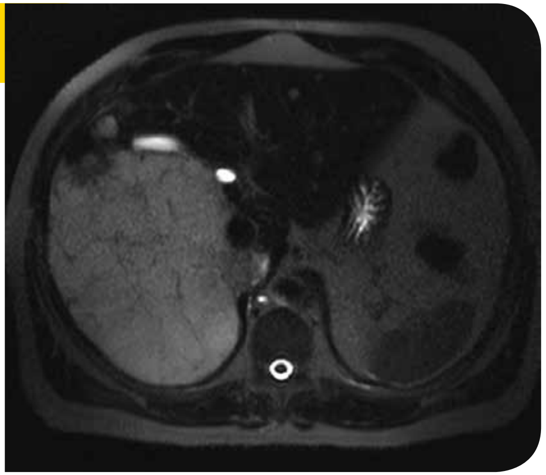
No ionising radiation

Magnetic resonance imaging (MRI) scans use a magnetic field and radio waves to take pictures of the body. It is especially helpful to collect pictures of soft tissue such as organs and muscles that don't show up on x-ray examinations.

MRI scans image water whereas normal x-rays image calcium. This makes MRI scans very useful because all tissues of the body contain various amounts of water. This allows high-resolution pictures of many organs and tissues to be taken that are invisible to standard x-rays.

The image on the right is the result of an MRI scan of the abdomen, specifically looking for an abnormality in the liver.

* In the Australian healthcare system primary care physicians/GPs are able to request limited types of MRI scans rebatable by Medicare. Please check www.health.gov.au/internet/main/publishing.nsf/Content/diagnosticimaging-aboutus.htm



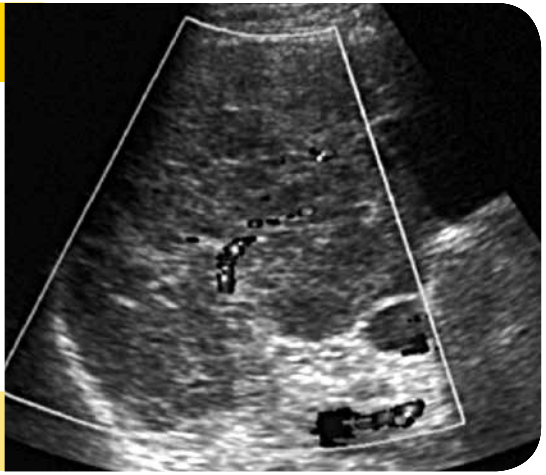
Ultrasound

No ionising radiation

Ultrasound is a scan used to study internal body structures. It works by sending out high frequency sound waves, directed at the internal body part being examined. The reflected sound, or 'echo', is recorded to create an image that can be viewed on a monitor. The sound waves are emitted from a small, hand-held probe. The high frequency of the sound used cannot be heard by the human ear.

An ultrasound scan is usually non-invasive; however, some scans are done with a special probe that is inserted into the vagina (for example, for special obstetric examinations), the rectum (for special prostate examinations) or the oesophagus (for special heart examinations).

The image on the right is the result of an ultrasound scan of the abdomen, specifically looking at an abnormality in the liver.



Information on diagnostic imaging and exposure to medical radiation is constantly being updated. This information was current at the time of production.

INFORMATION FOR HEALTH PROFESSIONALS

Typical effective doses from diagnostic medical exposure

Diagnostic procedure	Typical effective dose (mSv)	Equivalent period of background ionising radiation[a]	Estimated risk of cancer[b]
Radiographic examinations			
Limbs and joints (except hip)	<0.01	2 days	Negligible
Chest (single PA film)	0.02	5 days	Negligible
Hip	0.4	14 weeks	Negligible
Abdomen	0.7	24 weeks	Negligible
Thoracic spine	0.7	24 weeks	Negligible
Pelvis	0.7	24 weeks	Negligible
Lumbar spine	1.0	35 weeks	Negligible
Barium swallow	1.5	1 year	Negligible
CT head	2	1.3 years	1.1 in 10,000
IVU	2.4	1.6 years	1.3 in 10,000
Barium enema	7.2	4.8 years	4.0 in 10,000
CT chest[c]	8	5.3 years	4.4 in 10,000
CT abdomen or pelvis[c]	10	6.7 years	5.5 in 10,000
Radionuclide studies			
Lung ventilation (Xe-133)	0.3	10 weeks	Negligible
Lung perfusion (Tc -99m)	1	35 weeks	Negligible
Kidney (Tc-99m)	1	35 weeks	Negligible
Thyroid (Tc-99m)	1	35 weeks	Negligible
Bone (Tc-99m)	4	2.7 years	2.2 in 10,000
PET head (F-18 FDG)	5	3.3 years	2.8 in 10,000
Dynamic cardiac (Tc-99m)	6	4 years	3.3 in 10,000

[a] Background is the radiation we all get due to natural radioactivity and cosmic rays.

[b] Assumes a cancer risk of 5.5% per Sv. For younger people it may be 2 times greater, for older people significantly less (eg 50% for 60 year old). Note that the risks are not accurately known for low dose procedures.

[c] Recent CT scanners using low dose protocols are becoming available and may result in significantly lower doses than those quoted.

Diagnostic Imaging Pathways

Diagnostic Imaging Pathways is an online clinical decision support tool and educational resource for diagnostic imaging that is freely available to all health professionals. Diagnostic Imaging Pathways can be accessed at **http://www.imagingpathways.health.wa.gov.au/**

Responsibility of the doctor referring a patient for an imaging investigation

1. **Avoid unnecessary duplication of imaging investigation. This is aided by:**
   - Awareness of any previous imaging investigation performed (eg by other doctors).
   - Ensuring that steps are taken to ensure that previous images are available at subsequent consultations.
   - Awareness of the appropriate interval for serial imaging. This, of course, will vary with the disease process and the type of imaging.
2. **Ensure the results of the imaging investigation should potentially guide patient management.** However, it is acknowledged that exclusion of disease in certain circumstances may provide important reassurance for doctor and patient.
3. **Provide adequate clinical details to the imaging specialist.** Remember the adage “garbage in, garbage out”. In most situations a more meaningful report will be forthcoming if the imaging specialist is provided with the clinical history relevant to the examination and the question to be answered by the investigation.
4. **Ensure that imaging investigations are not a substitute for examining the patient.**
5. **Be aware that many imaging investigations have risks.** Referring clinicians should be sufficiently aware of those risks to determine whether the potential benefits of the test outweigh the potential risks. For any interventional procedure it is the Imaging specialist’s responsibility to obtain informed consent from the patient or relative, or to delegate this responsibility to a doctor who knows all the significant risks. However for diagnostic tests it is normally the referring doctor’s responsibility to ensure that the benefit will exceed the risk.
6. **Consult with imaging specialist colleagues when appropriate.** There are often a number of available investigations in a particular clinical situation. The choice of the appropriate test in what may be a complex clinical problem will be facilitated by consultation.
7. **In younger patients, choose imaging that does not employ ionising radiation (eg ultrasound, MRI) in preference to those using ionising radiation if possible and appropriate.** source: www.imagingpathways.health.wa.gov.au/ cited March 2011

What patients need to know

Patients need to be informed about a proposed procedure, allowing them to make an educated decision about their own health care.

The elements that a patient needs to be educated about before making an educated decision are:

- the nature of the imaging procedure
- the benefits and risks
- alternative forms of investigation that provide the same results
- benefits and risks of the alternative investigations
- benefits and risks of not undergoing investigation.

Remember, if radiological investigations are done for a specific problem, the potential benefit *significantly* outweighs the very small risk.

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