Nuclear medicine

Answering your questions

Australian Government

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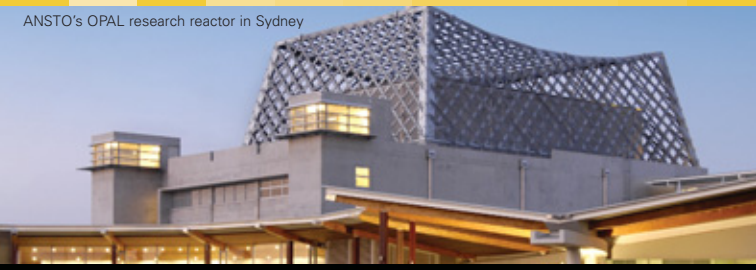
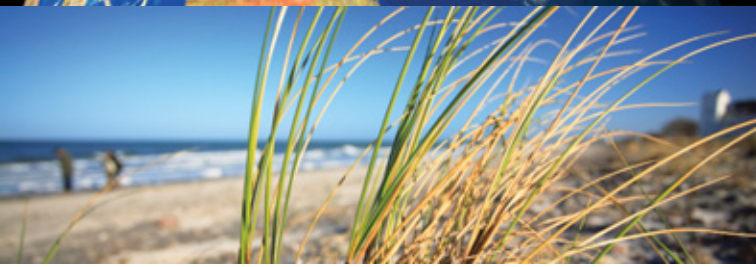
Nuclear-based science benefiting all Australians



ANSTO's OPAL research reactor in Sydney



What is nuclear medicine?

This is a branch of medicine that uses radiation from radioactive tracers to provide information about the function of specific organs. In some cases, radioactivity can be used to treat certain conditions such as an overactive thyroid.

What is radiation?

Radiation is a type of energy, which exists in our environment in many forms and comes from both natural and man-made sources. Light that allows us to see and the warmth we get from the sun or from nature are natural forms of radiation. Examples of man-made radiation include the microwave radiation that is used for cooking and radio waves for communication over long distances.

Ionising radiation comes from both natural and man-made sources. It comes from outer space, the sun, the earth, the air, our food and drink and from the buildings we live in. This is the natural background radiation to which everyone is exposed. Each of us receives a small dose of naturally occurring radiation on an annual basis. Nuclear medicine studies use ionising radiation, as do x-ray studies.

Nuclear medicine is extremely safe because the radioactive tracers or radiopharmaceuticals commonly used are quickly eliminated from the body through its natural functions. In addition, the tracers used rapidly lose their radioactivity. In most cases, the dose of radiation necessary for a scan is very small. For example, a patient having a lung scan is exposed to the same dose of radiation they would receive from eight return air flights between Sydney and London.

What is a half-life?

Nuclear medicines used for diagnosis or treatment generally have short half-lives. A half-life is the time it takes for the level of radioactivity to drop to half the starting level. Nuclear medicines typically have a half-life of several hours or days. This means they rapidly lose their radioactivity level within the predetermined half-life.

Where are radiopharmaceuticals produced?

Australia is certainly a lucky country in the sense that it is one of the very few nations in the world to produce the radioactive tracers necessary for diagnostic nuclear medicine. In fact, without the ability to produce radiopharmaceuticals in Australia, we would have to import them from as far away as Europe, Canada and South Africa.

Radiopharmaceuticals are manufactured in Sydney by the Australian Nuclear Science and Technology Organisation (ANSTO) using a cyclotron and its nuclear research reactor, OPAL.

It is necessary to have both the research reactor and the cyclotron as each produces different types of radiopharmaceuticals.

The manufacturing process is regulated by strict quality-control requirements as approved by the Australian Government.

The radiopharmaceuticals are supplied to nuclear medicine centres across Australia. Every year thousands of people are diagnosed and treated at these centres. Without access to this vital technology, many Australians would be facing a reduced quality of medical care.

Australia also exports radiopharmaceuticals to the United States, Europe and Asia.

What is the difference between radiopharmaceuticals made in a cyclotron and those made in a nuclear reactor?

The nucleus of an atom contains two types of particles – neutrons and protons. Non-radioactive atoms have a 'stable ratio' of neutrons and protons in the nucleus, while radioactive atoms have an 'unstable ratio'. Radioactive atoms are made by adding either extra neutrons or extra protons.

Atoms with extra neutrons in the nucleus are neutron-rich; they are produced in a nuclear reactor – this is the great majority of medically useful radiopharmaceuticals. Atoms with extra protons in the nucleus are proton-rich and are produced in a particle accelerator such as a cyclotron - they complement those manufactured in nuclear reactors.

Neutron-rich and proton-rich radioisotopes decay by different means and thus have different radioactive properties and different medical uses.

Both types of radioisotopes are needed to service all of Australia's nuclear medicine needs. Over 80 per cent of the radioisotopes used in medical procedures, including the most commonly used radiopharmaceutical technetium-99, can only be produced economically in a nuclear research reactor.

When is a nuclear medicine scan needed?

There is about a one in two chance of an Australian needing a nuclear medicine scan during his or her lifetime. Scans using radiopharmaceuticals can diagnose numerous conditions. Scans of the heart, thyroid, lungs and kidney are common. However, by far the majority of scans involve the skeleton. These are usually carried out to diagnose infection, tumour spread, and fractures or sports injuries.

Should I prepare for a scan?

Some scans may require special preparation. As with other tests, if you are pregnant or if there is any possibility that you may be pregnant or if you are breastfeeding, you must tell your physician. It is important that you read all the material given to you prior to your appointment.

What can I expect when I have a scan?

When you undergo a scan, a radiopharmaceutical will be given, either by injection into a vein, by mouth or through a breathing device. The radiopharmaceutical will concentrate in the particular part of your body under investigation.

Sometimes you may have to wait for a few hours or even a day or two after the radiopharmaceutical has been administered for the scan to be done. This is because it may take a while for the radiopharmaceutical to lodge in the part of your body to be examined.

The radiopharmaceutical continuously gives off invisible radiation, known as gamma rays. The images are stored digitally on computer for reporting by doctors who will be able to tell if the part of your body being tested is functioning normally.

Are there different types of scans?

Yes, there is gamma camera imaging and positron emission tomography (PET) imaging.

Gamma imaging operates in two different modes, PLANAR imaging and single photon emission computed tomography (SPECT) imaging.

If your doctor refers you for a nuclear medicine scan, one or more of the following methods may be used:

PLANAR imaging

PLANAR is the most common of the three methods. It involves the injection into the body of a small amount of a chemical substance tagged with a radioactive tracer. Depending on the chemical substance used, the radiopharmaceutical concentrates in the part of the body being investigated, for example the skeleton, lungs, heart or liver, and gives off gamma rays. A gamma camera produces a two-dimensional image of the radioactivity occurring in that organ.

SPECT imaging

SPECT is also widely used and the process of injecting a radioactive tracer is the same as the PLANAR technique. Instead of being stationary, the gamma camera moves around the body providing a series of images. This takes about 20-30 minutes. SPECT and PLANAR imaging are highly convenient technologies as they use radiopharmaceuticals, which can be easily distributed, stored and mixed ready for use at nuclear medicine clinics and hospitals across Australia.

PET imaging

PET is a very similar technique to SPECT but uses different radiopharmaceuticals. The radiopharmaceuticals required for PET have very short half-lives and are produced by a cyclotron. The most common radiopharmaceutical used is radioactive sugar. PET studies require you to lie

quietly for up to one hour after the injection so that the radiopharmaceutical localises correctly rather than going to your muscles.

Will I have to stay in hospital?

Patients having a diagnostic scan will often be asked to stay in the nuclear medicine department for a few hours, although in some cases patients are asked to return for a number of visits or to stay in hospital for a short period.

If you are undergoing therapy, particularly for an overactive thyroid gland, you will probably be treated as an outpatient and will not need to stay in hospital. If you do need to stay for certain types of therapy, then you will usually only be in hospital for two or three days. This is not because of any risk to your health but because doctors want to ensure that radioactive materials are dealt with safely when they are excreted from your body.

What does nuclear medicine treatment involve?

By far the widest application of nuclear medicine is for diagnosis. However, there are a number of occasions when radioactive materials are used to treat certain conditions, particularly cancer. This is known as therapy.

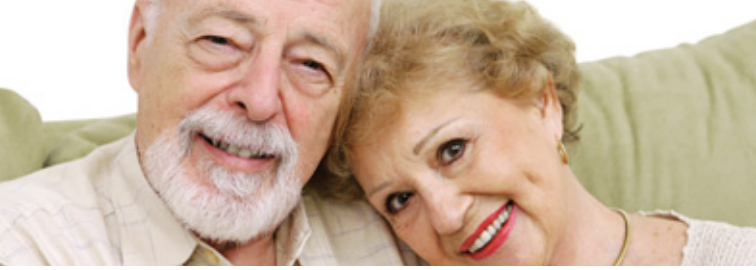
Nuclear medicine therapy usually involves taking radiopharmaceuticals orally (either in capsule or liquid form) and the most common conditions treated in this way are overactive thyroids and thyroid cancer. Radiopharmaceuticals are also injected into the body, usually the joints, to treat certain types of arthritis. Newer treatments involve the intravenous injection of radiopharmaceuticals for the relief of pain from tumours that have spread to bone. In Australia many patients are treated with radiopharmaceuticals that have a medical effect on their bodies. For most, one dose is all that is required.

Are there any side effects?

Side effects are extremely rare for diagnostic scans. When radiation or radiopharmaceuticals are used in therapy, there are sometimes minor side effects. These will be explained to you by the nuclear medicine staff together with measures to reduce or avoid the symptoms.

Who carries out nuclear medicine procedures?

If your doctor recommends you have a scan or nuclear medicine treatment, you will be placed in the care of a team of specially trained professionals. Physicians, technologists, pharmacists and nurses will ensure that you receive a high level of care and that your doctor is provided with accurate reports on your condition.



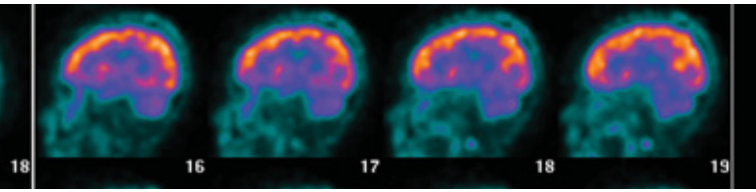
What happens after a scan or therapy?

The specially trained physicians will report on the scan's appearance and send the results to your doctor to evaluate, together with those of any other tests you may have had. In the majority of cases, you will be able to continue your daily activities as usual.

What are the benefits of nuclear medicine?

Nuclear medicine enables doctors to produce a quick and accurate diagnosis for a wide range of conditions and diseases at any age. In turn, this allows the appropriate treatment to begin as early as possible, which gives a far greater chance of being fully effective. In addition, the tests are painless and most scans expose patients to only a minimum amount of radiation. It is a very accurate way to examine whether some tissues are functioning properly.

Therapy using nuclear medicine is an effective, safe and relatively inexpensive way of controlling and in some cases, eliminating certain conditions such as an overactive thyroid, thyroid cancer and certain types of arthritis. Nuclear medicine is a vital part of healthcare as it gives many people the opportunity of continuing to live full and healthy lives.



ANSTO Radiopharmaceuticals (ARI) is a subsidiary of the Australian Nuclear Science and Technology Organisation (ANSTO) which is Australia's centre of nuclear expertise specialising in the applications of nuclear science.

ANSTO is based at Lucas Heights in southern Sydney; it is a publicly owned organisation overseen by the Federal Government.

Members of the public are welcome to visit ANSTO for organised tours.

If you wish to find out more about tours, to understand how nuclear science improves the lives of Australians, or to obtain further information, please call ANSTO on (02) 9717 3111.

Produced by ARI in cooperation with the Australia and New Zealand Society of Nuclear Medicine (ANZSNM) and the Australia and New Zealand Association of Physicians in Nuclear Medicine (ANZAPNM).

For further information, please contact the nuclear medicine department at your nearest hospital.

Nuclear medicine, answering your questions

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