

Medical Use of Radioisotopes



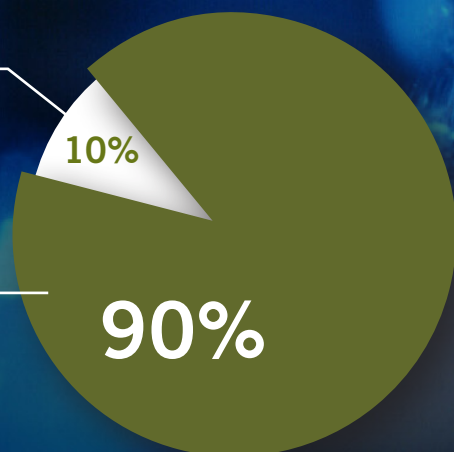
Therapy

Radioisotopes prove to be useful in the application of brachytherapy, the procedure for using temporary irradiation close to the area of disease (i.e. cancer)



Medical Imaging

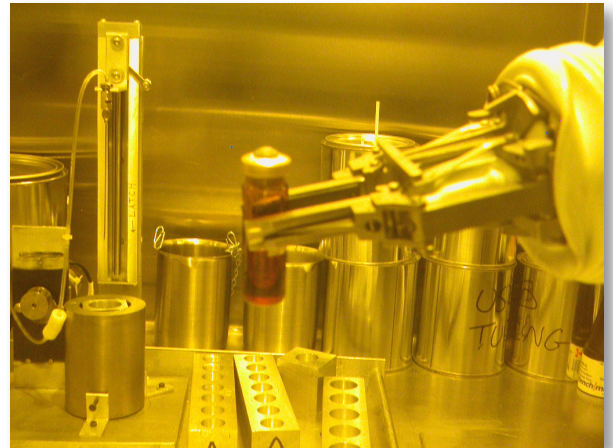
Thanks to radioactive isotopes, images can be obtained via gamma camera or a PET scan in nuclear diagnostics. Gamma camera can accurately detect disease progression and staging in vital organs.



For a U.S. population of over 300 million people, there are some 16 million nuclear medicine procedures per year.¹

The field of nuclear medicine uses radiation to provide diagnostic information about the functioning of humans or information on how to treat them. Tens of millions of nuclear medicine procedures are performed each year and the demand for radioisotopes for medical use is increasing rapidly.

We can only scratch the surface of the many amazing applications of radiation and radioisotopes. We won't be able to discuss all of them, but the following should give you an appreciation about what they do for us today.



Over 10,000 hospitals worldwide use radioisotopes in medicine, and about 90 percent of the procedures are for diagnosis.

Areas of Medicine Where Radiation is Used

Sterilization of medical products

- Today, over half of all medical equipment used in modern hospitals is sterilized using radiation.

New drug testing

- Over 80% of all new drugs are tested with radioactive tagging before approval.²

Medical Imaging

- Approximately 68 million CT scans are performed in the U.S according to the National Council on Radiation (NCRP).

Therapy

- Approximately 10% of medical procedures use radiation to treat a variety of diseases, including many types of cancers, heart disease, gastrointestinal, endocrine, neurological disorders and other abnormalities within the body.^{2,4}



Medical Imaging

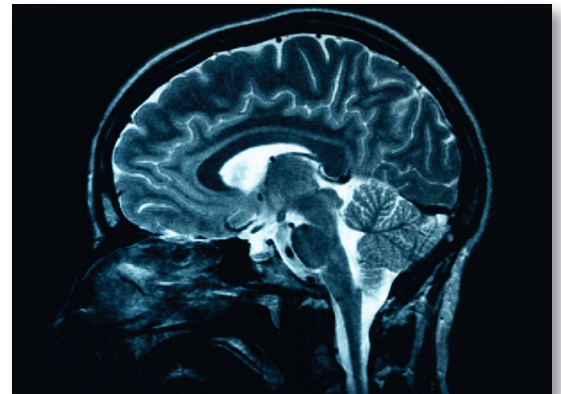
X-rays

- X-ray images are produced by placing a patient between an x-ray tube and a photographic plate. An image on the film of the area exposed can then be reviewed.
- Common x-rays are made of teeth, bones, and breasts (mammograms).



Magnetic Resonance Imaging (MRI)

- MRI is an imaging technique used to visualize internal structures of the body in detail. MRI can create more detailed images of the human body than is possible with X-rays.
- This procedure uses a magnetic field and pulses or radio waves to make pictures of organs and structures inside the body. The water in our bodies is made up of millions of atoms that are magnetically charged. When placed in a magnetic field these atoms line up with a field much like a compass points to the North Pole.

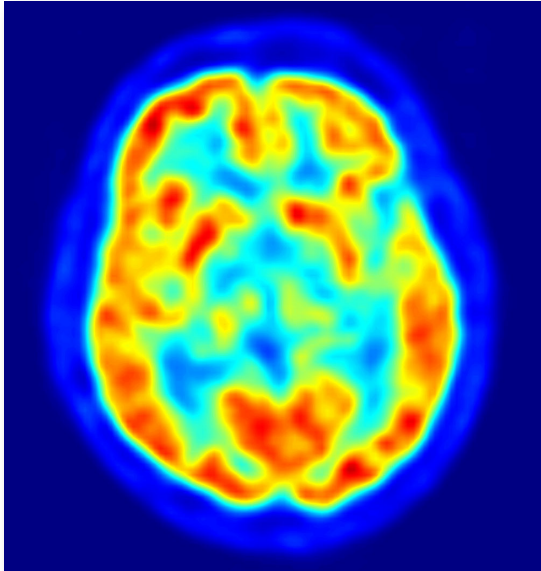


Computerized Tomography (CT) scan

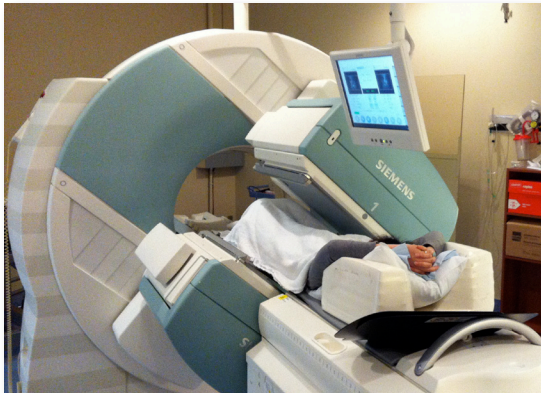
- This procedure can provide a 3D x-ray, often used to create full motion heart scans for patients with high risk of heart disease or used to detect tumors and brain bone trauma.



Medical Imaging / Radiotracers



This is a slice of the brain of a man taken with PET. The red area shows more accumulated tracer substance and blue areas are region where low to no tracer has been accumulated.



SPECT imaging acquires multiple 2D images from multiple angles, and then this information is processed to yield a 3D image.

Positron Emission Tomography (PET)

- This nuclear medical imaging technique involves the injection into the body of an isotope that decays by positron emission that is the beta plus (B^+) particle. When this positron encounters an electron, a beta minus particle, they annihilate each other and produce two photons. The energy and path of these photons leaving the body can then be used to give an accurate picture of the area where the isotope was absorbed.

Single Photon Emission Computed Tomography (SPECT)

- SPECT is similar to PET in its use of radioactive tracer material and detection of gamma rays. In contrast with PET, however, the tracer used in SPECT emits gamma radiation that is measured directly. Where PET tracers emit positrons that annihilate with electrons up to a few millimeters away, causing two gamma photons to be emitted in opposite directions. A PET scanner detects these emissions coincident in time, which provides more local radiation event information and thus higher resolution images than SPECT. SPECT scans, however, are significantly less expensive than PET scans, in part because they are able to use longer lived, more easily obtainable radioisotopes than PET needs.



Mo-99 Shortage

Molybdenum-99, **Mo-99** is the most in demand medical isotope. It can be shipped from a nuclear reactor where it is created as a fission product, to the point of use as it has a reasonably long half-life of 66 hours. Its decay product, Technetium 99m, with a 6 hour half-life, is used as a tracer.

The supply of medical isotopes is a priority for the United States. The U.S. is currently taking actions to support the long-term reliability of supply of this vital commodity for the medical community and ensure that patient needs are met around the world.³

The world's supply of Molybdenum 99, Mo-99 is in trouble. The use of this isotope is growing, and is considered the most important medical radiochemical in the world.

DID YOU KNOW?

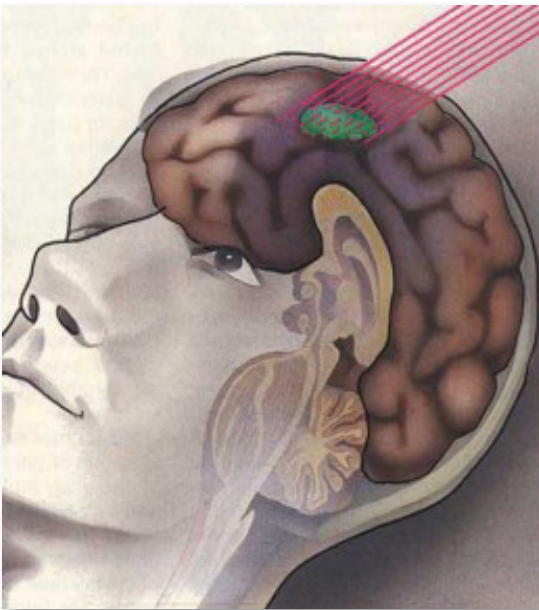
- 85% of all nuclear medicine examinations use Mo/Tc Generators for diagnostics of liver, lungs, bones.²
- 4 out of 5 Mo-99 generating nuclear reactors are nearing the ends of their service life and will be decommissioned or need extensive overhauls in the next few years.
- Non-reactor technetium can be produced in small quantities from cyclotrons and accelerators, in a cyclotron by bombarding a Mo-100 target with a proton beam to produce Tc-99m directly, or in a linear accelerator to generate Mo-99 by bombarding a Mo-100 target with high-energy X-rays.⁵

The Use of Radiation in Medical Therapy

Approximately 10% of all medical procedures use radiation.²



Today, radiation is used internally in the treatment of other cancers, and nearly half of all cancer patients in the U.S. receive radiation treatment at some point in their therapy.



Boron neutron capture therapy can kill tumors without harming healthy neighboring tissue.

Radiation in medical therapy was first applied to the treatment of thyroid cancer. The patient drinks a determined amount of the solution spiked with radioactive iodine-131. This radioisotope preferentially lodges in the thyroid. The beta emissions of this radioisotope subsequently target and destroy the cancer in the thyroid.

External radiation therapy uses an external beam of radiation to focus on cancerous growths. An incident beam of x-rays or protons is moved around the patient in a precise manner so that the beam remains focused on the tumor minimizing the length of time the penetrating radiation beam doesn't remain on any of the healthy cells for very long.

Internal radionuclide therapy can be administered by planting a small radiation source, usually a gamma or beta emitter in the target area(s). Iridium 192 implants are used often in the brain and breast regions. They are produced in wire form and are introduced through a catheter to the target area. After administering the correct dose, the implant wire is removed.

Boron Neutron Capture Therapy (BNCT)

In this procedure boron is injected into the patient to preferentially concentrate at the tumor site. A neutron beam is then focused on the boron. Neutrons react with the boron to produce alpha particles that destroy the malignant cells in the immediate vicinity of the concentrated boron. Since alpha particles are stopped at a very short distance from their point of origin, intense radiation damage is localized.

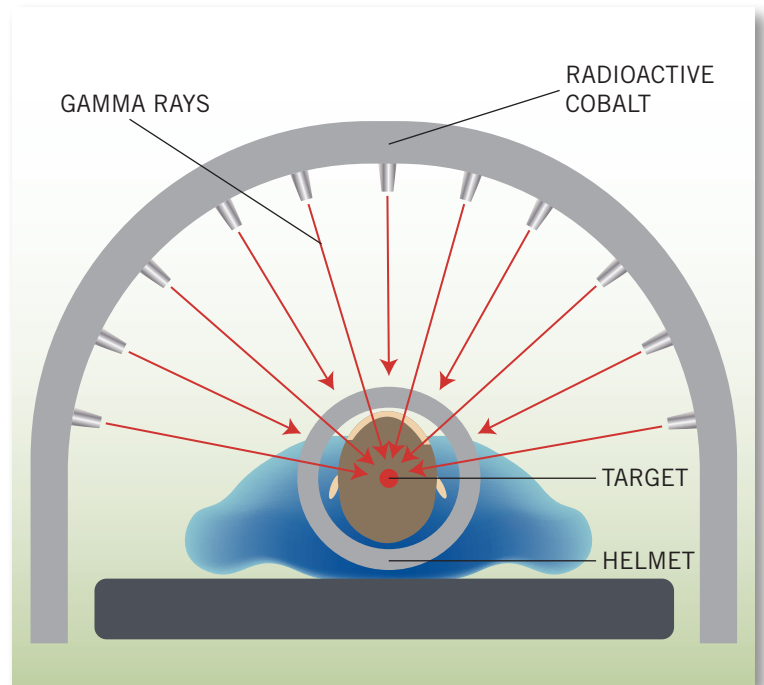
Therapy

Gamma Knife Radiosurgery (CyberKnife)

Minimizing injury to healthy cells, radiation therapy involves rotating an external radiation beam around the patient. The radiation from the radioactive source is delivered from many directions, with the beam continually focused on the target abnormality with only small amounts of radiation passing through healthy tissue.

Brachytherapy is a form of internal radio therapy where a radiation source is placed inside or next to the area requiring treatment. Brachytherapy involves the precise placement of short-range radioisotopes directly at the site of the cancerous tumor. These are enclosed in a protective capsule or wire that allows the ionizing radiation to escape. The radiation treats and kills surrounding tissue, but prevents the charge of radioisotopes from moving or dissolving in the body fluids. The capsule may be removed later, or with some isotopes, it may be allowed to remain in place for prolonged treatment. A key feature of brachytherapy is that the radiation affects a localized area around the radiation source. In addition, if the patient moves, or if there's any movement of the tumor within the body during treatment, the radiation source retains its correct position in relation to the tumor.

There is no doubt that medical research will find more ways to use radiation and radioisotopes to improve our lives.



Accelerated partial breast irradiation (APBI) is a form of brachytherapy that involves the insertion of a radioactive source to kill breast cancer cells that may remain after lumpectomy surgery.

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