Radioisotopes in Medicine

(Updated December 2016)

- **Nuclear medicine uses radioisotopes to provide diagnostic information about the functioning of a patient's organs, tissues and vital systems. Therapeutic procedures using radioisotopes are not common.**
- **Nuclear medicine can be used to treat some medical conditions, especially cancer, using radioisotopes to sustain or destroy particular tissues.**
- **Over 80 million nuclear medicine procedures are performed each year, and demand for nuclear medicine is increasing at about 10% per year.**
- **Technetium-99 medical radioisotope is also an important use of radioisotopes.**

The attributes of naturally decaying atoms, known as radioisotopes, give rise to several applications across many industries including medicine, food, agriculture, manufacturing, and environmental protection.

There is widespread awareness of the use of radiation and radioisotopes in medicine, particularly for diagnosis (identification) and therapy (treatment) of various medical conditions. In developed countries a quarter of the world's population benefits from nuclear medicine. Nuclear medicine procedures are performed on about one in every hundred Australians or about 1 million per year.

Nuclear medicine uses radiation to provide information about the functioning of a person's specific organs, or to treat certain diseases. Most of the radiation used in nuclear medicine originates from man-made radioisotopes. The physical, chemical, and biological properties of these isotopes can be tailored-made and incorporated into pharmaceuticals which are then taken into the body by injection, ingestion or inhalation. The radiation emitted from these pharmaceuticals is then monitored with the use of radiation tracers or medicines.

Nuclear medicine is a relatively non-invasive form of medical medicine, and about 50% of the procedures are for diagnosis. The most common radioisotope used in diagnosis is technetium-99 (Tc-99), and about 80% of nuclear medicine procedures are accounting for about 80% of all nuclear medicine procedures and 80% of diagnostic scans in nuclear medicine are using Technetium-99.

A developed countries 25% of all people will undergo the frequency of diagnostic nuclear medicine procedures, and the frequency of therapy with radioisotopes about one in 1000, in the 250 there are over 20 million nuclear medicine procedures performed each year, and demand for nuclear medicine is increasing at about 10% per year. Most of these are for diagnostic purposes. The use of radiopharmaceuticals in diagnosis is growing at over 100 per year.

The global radioisotope market was valued at $150 million in 2016, with medical radioisotopes accounting for about 80% of the market, and Australia's share is about 2%. The global market is dominated by a few large companies, in contrast to Australia's small share of the market, which is dominated by small companies.

Nuclear medicine was developed in the 1950s by physicians with an extensive engineering, chemistry, and radiation 1970 to 1980 and 1990 to 2000 the use of nuclear medicine in Australia, Australian Nuclear Medicine Society (ANMS) and Australian Institute of Radiopharmaceuticals (AIRP) (1) (2) (3) (4) (5) (6) (7) (8) (9) (10) (11) (12) (13) (14) (15) (16) (17) (18) (19) (20) (21) (22) (23) (24) (25) (26) (27) (28) (29) (30) (31) (32) (33) (34) (35) (36) (37) (38) (39) (40)

Radioisotopes of gold and ruthenium are also used in brachytherapy.

* fission product

Cyclotron radioisotopes

Actinium-225 (10 d):
Used for TAT especially prostate cancers.

Astatine-211 (7.2 h):
Use for TAT.

Bismuth-213 (46 min):
Used for TAT.

Carbon-11, Nitrogen-13, Oxygen-15, Fluorine-18:
These are positron emitters used in PET for studying brain physiology and pathology, in particular for localising epileptic focus, and in dementia, psychiatry, and neuropharmacology studies. They also have a significant role in cardiology. F-18 in FDG (fluorodeoxyglucose) has become very important in detection of cancers and the monitoring of progress in their treatment, using PET.

Cobalt-57 (272 d):
Used as a marker to estimate organ size and for in-vitro diagnostic kits.

Copper-64 (13 h):
Used to study genetic diseases affecting copper metabolism, such as Wilson's and Menke's diseases, for PET imaging of tumours, and also cancer therapy.

Copper-67 (2.6 d):
Beta emitter, used in therapy.

Fluorine-18 (110 min) as FLT (fluorothymidine), F-miso (fluoromisonidazole), 18F-choline:
It decays with positron emission, so used as tracer with PET, for imaging malignant tumours.

Gallium-67 (78 h):
Used for tumour imaging and locating inflammatory lesions (infections).

Gallium-68 (68 min):
Positron emitter used in PET and PET-CT units. Derived from germanium-68 in a generator.

Germanium-68 (271 d):
Used as the 'parent' in a generator to produce Ga-68.

Indium-111 (2.8 d):
Used for specialist diagnostic studies, *e.g.* brain studies, infection and colon transit studies. Also for locating blood clots, inflammation and rare cancers.

Iodine-123 (13 h):
Increasingly used for diagnosis of thyroid function, it is a gamma emitter without the beta radiation of I-131.

Iodine-124 (4.2 d):
Tracer, with longer life than F-18, one-quarter of decays are positron emission so used with PET. Also used to image the thyroid using PET.

Krypton-81m (13 sec) from rubidium-81 (4.6 h):
Kr-81m gas can yield functional images of pulmonary ventilation, *e.g.* in asthmatic patients, and for the early diagnosis of lung diseases and function.

Rubidium-82 (1.26 min):
Convenient PET agent in myocardial perfusion imaging.

Strontium-82 (25 d):
Used as the 'parent' in a generator to produce Rb-82.

Thallium-201 (73 h):
Used for diagnosis of coronary artery disease other heart conditions such as heart muscle death and for location of low-grade lymphomas. It is the most commonly used substitute for technetium-99 in cardiac-stress tests.

Notes & references

OECD/NEA 2012, A Supply & Demand Update of the Mo-99 Market
IAEA 2015, Feasibility of Producing Molybdenum-99 on a Small Scale Using Fission of Low Enriched Uranium or Neutron Activation of Natural Molybdenum, Technical reports series #478
Australian Nuclear Science and Technology Organisation (ANSTO) webpage on Using radioisotopes in research

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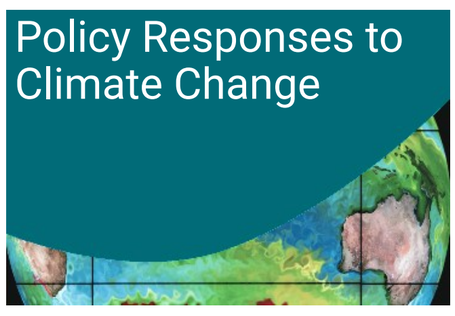

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