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RADIOTOXICOLOGY

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- **The radiotoxicology - biokinetics and the biological effects of the internally deposited radionuclides.**
  - ✓ if we know the **quantitative relationship** among **exposure, intake, uptake, deposition, and elimination** of a radioisotope, we can calculate the **radiation dose** from a **given exposure**.

Models for internal dosimetry consider **two categories** of parameters: **radiological** and **biological**.

a) **Radiological parameters** are:
- **type of radiation;**
- **energy of the radiation;**
- **half-life of the radionuclide;**
- **radioactive progeny;**

b) **Biological parameters** are:
- **chemical form;**
- **ingestion rate;**
- **inhalation rate;**
- **particle size;**
- **respiration rate;**
- **metabolic pathway;**
- **retention and excretion;**
- **organ size;**

- **Occupational exposure guidlines are 100 mSv in 5 years (average, 20 mSv per year) with a limit of 50 mSv in any single year.**

- **General public standard is 1 mSv per year. (Natural background radiation is approximately 3 mSv/year.)**

Recommended exposure limits are set by International Council on Radiation Protection (ICRP).

- **Soluble radionuclides** fall into one of **three categories**, according to their **metabolic pathways** and distribution within the body:

1. Radionuclides that are uniformly **distributed within the body**, such as **tritium** (H^3), **cesium** (Cs^{137}) etc.
2. Radionuclides that are *concentrated in specific organs*, such as **mercury in the kidney**, **iodine in the thyroid**, etc.
3. Radionuclides that are **deposited in the skeleton**, such as **radium** (Ra^{226}), **strontium** (Sr^{90}), etc.

- During the **early stages** of nuclear accidents mixtures of **noble gases (e.g. krypton, xenon**), iodine and particulate material may be released in the atmosphere and can be **intaken in the human body**.
- Of the **radionuclides** potentially available for release in a **nuclear reactor accident** in the **short-term**, radioiodines, particularly **iodine^{131}**, are by a **far the most significant in view of their huge quantities in the reactor core and their volatility**.

- The physical half-life of the **iodine 131** is **8.05** days. It emits **β**-particle and **γ**-rays.
- **Iodine**, including the **isotopes 131, 133** is **rapidly** and **completely absorbed** by the **gastrointestinal tract** within 30 to 60 minutes of ingestion
- Inhaled radionuclides reach equilibrium in the body within about 30 minutes

- **Iodine** is **rapidly concentrated** by the **thyroid**, reaching its maximum euthyroid uptake in 48 hours
- Iodine is almost **instantaneously synthesized** into **thyroid hormones**, primarily **thyroxin**, which is only **slowly released**.

- The thyroid can be protected using stable form of iodine.

❑ **If 100 mg of KI** (stable form of iodine) is administered at the **same time** or **shortly before** exposure to **radioiodine**, **thyroid blockade is almost 97%** complete, and the thyroid takes up **only 3%** of the administered radioiodine.

- ✓ **Potassium iodide given 3 hours later reduces** the uptake to **only 50%** of control **value**, and **after 6 hours** KI **no longer** has a **significant protective effect**.
- ✓ If there is **no new exposure** to radioiodine, KI administration should be continued **for 2 or 3** additional days;
- ✓ If **exposure to I^{131} persists**, then administration **of KI should be continued**.

- The main biological effects of the **radioiodine** are **hypothyroidism** and **thyroid cancer**.
- During the **intermediate and late phases after nuclear accident the most dangerous radionuclides** are **Cesium-137** and **Strontium-90**.
- **Cesium-137** is **beta and gamma emitting** isotope. Its **physical half-life is 30 years**.
  - ✓ the **effective half-life is 70 days**.
  - ✓ the cesium-137 is **uniformly distributed within the body**.
  - ✓ the radiocesium damages **the most radiosensitive tissues**: **haematopoeitic, reproductive**.

- **Strontium-90** is only **beta emitting** radionuclide.
  - ✓ its **physical half-life is 28 years**.
  - ✓ the **effective half-life is 15 years**.
  - ✓ the radiostrontium is deposited mainly in the **skeleton**
  - ✓ the most important biological effect of strontium is **osteosarcoma**.

Treatment of internal contamination with radionuclides

Following **internal contamination** there is usually a **period of time** before the radionuclide has been **absorbed, transported and taken up** tissue cells. The absorption from the lung, gut, or wound can sometimes be **reduced** by **chemical manipulation** in the **GI tract**, or by **hastening** the **passage** of the material through the body.

- **Alkalizing the stomach** may cause the formation of relatively **insoluble hydroxides** or will at least keep the **pH high** enough to **reduce solubility** of some metal salts.

  - Metals such as **copper, iron, or plutonium** are generally more available for **later absorption** after spending some time in the **acid milieu** of the stomach.

  - With **chromium, opposite is true**. **Acid gastric juice** reduces **hexavalent chromium** to the **poorly absorbed** trivalent ion.

  - The administration of **cathartics** such as magnesium sulfate will **shorten** the **intestinal transit** time, thereby reducing absorption and radiation exposure to the gut wall and nearby tissues.

- **Once absorbed**, uptake can be reduced by the use of **blocking agent, isotopic dilution**, or **chelating agents**.

  A **blocking agent** is a chemical that **saturates a tissue** with a nonradioactive element, thereby **reducing the uptake** of the radionuclide.

  Isotopic dilution refers to the administration of **large quantities** of the **stable isotope** of the radionuclide so that, the **opportunity** for **incorporation** of atoms of the radionuclide is **lessened**.

  Chelating agent binds metal into **complexes**, prevents tissue uptake and allows **urinary excretion**. If given promptly, **diethylenetriaminepentacetic acid (DTPA**) will greatly reduce the uptake of **absorbed 232 Pu** in the **skeleton**. Chelating agents such **as EDTA, DTPA, BAL, penicillamine, or deferoxamine** are sometimes useful after uptake, but their effectiveness is greatly reduced.

Iodine Prophylaxis

Recommended single dosage of stable iodine according to age group

Age group	Mass of Iodine(mg)	Mass of KI Potassium Iodide (mg) Tablets: 65 mg, 130 mg, 250 mg	Mass of KIO3 Potassium Iodate mg	Fraction of 100 mg tablet (5% tincture of Iodine (drops)
Adults and adolescents (over 12 y)	100	130	170	1 (2, ½)
Children (3-12 years)	50	65	85	1/2
Infants (1 m to 3 y)	25	32	42	1/4 20 drops
Neonates (birth to 1 m)	12.5	16	21	1/8 10 drops