**Read theoretical information on the topic!**

**Topic: The use of ionizing radiation sources in medicine. Radiation protection during the exploitation of ionizing radiation sources**

**The objective**: to improve theoretical knowledge on radiation safety principles in working with ionizing radiation sources.

**The main questions of the study:**

1. Types of radiation exposure.
2. The use of ionizing radiation sources in medicine.
3. Radiation protection during the exploitation of ionizing radiation sources.
4. Radiation control and medical monitoring.
5. Radioactive wastes.

**Question 1**

**Type of radiation exposure**

Radiation exposure may be internal or external.

**External exposure** to ionizing radiation can also result from external irradiation (e.g. medical radiation exposure to X-rays). External irradiation stops when the radiation source is shielded or when the person moves outside the radiation field.

The source of radiation can be a piece of equipment that produces the radiation, like an x-ray machine, or it can be from radioactive materials in a container. The exposure occurs when the radiation from these sources interacts with our body and the dose occurs when the radiation leaves some of the energy in our body.

External exposure is exposure which occurs when the radioactive source is outside (and remains outside) the organism which is exposed. Examples of external exposure include:

* A person who places a sealed radioactive source in his pocket
* A space traveller who is irradiated by cosmic rays
* A person who is treated for cancer by teletherapy.

**Internal exposure** occurs when the radioactive material enters the organism, and the radioactive atoms become incorporated into the organism. Internal exposure to ionizing radiation occurs when a radionuclide is inhaled, ingested or otherwise enters into the bloodstream (e.g. injection, wounds).

Internal exposure stops when the radionuclide is eliminated from the body, either spontaneously (e.g. through excreta) or as a result of a treatment. Below there are a series of examples of internal exposure.

* The exposure caused by potassium-40 present within a normal person.
* The exposure to the ingestion of a soluble radioactive substance, such as Sr-89 in cows' milk.
* A person who is being treated for cancer by means of radiopharmaceuticals where a radioisotope is used as a drug (usually a liquid or pill).

When radioactive compounds enter the human body, the effects are different from those resulting from exposure to an external radiation source. Especially in the case of alpha radiation, which normally does not penetrate the skin, the exposure can be much more damaging after ingestion or inhalation.

**Question 2**

**The use of ionizing radiation sources in medicine**

Ionising radiation is used in medicine in 3 ways:

- diagnostic radiology, which uses x-ray machines to obtain images of the inside of the patient’s body

- nuclear medicine, which uses radioactive substances introduced into the patient for diagnosis or treatment

- radiotherapy, which uses many types and sources of ionising radiation to cure or relieve symptoms of cancer and other diseases

So, ionizing radiation is used in medicine for diagnosis or treatment of diseases.

Ionizing radiation is used daily in hospitals and clinics to perform diagnostic imaging procedures. The most commonly mentioned forms of ionizing radiation are x rays and gamma rays. Procedures that use radiation are necessary for accurate diagnosis of disease and injury. Physicians and technologists performing these procedures are trained to use the minimum amount of radiation necessary for the procedure. Benefits from the medical procedure greatly outweigh any potential low risk of harm from the amount of radiation used.

Which **types of diagnostic imaging procedures** use radiation?

• ***In x-ray procedures***, x rays pass through the body to form pictures on film or on a computer or television monitor, which are viewed by a radiologist. If you have an x-ray test, it will be performed with a standard x-ray machine or with a more sophisticated x-ray machine called a CT or CAT scan machine.

• ***In nuclear medicine procedures***, a very small amount of radioactive material is inhaled, injected, or swallowed by the patient. If you have a nuclear medicine exam, a special camera will be used to detect energy given off by the radioactive material in your body and form a picture of your organs and their function on a computer monitor. A nuclear medicine physician views these pictures. The radioactive material typically disappears from your body within a few hours or days.

**Radiation therapy.**

Also called radiotherapy and irradiation. The use of high-energy radiation from x-rays, gamma rays, neutrons, protons, and other sources to kill cancer cells and reduce tumors. Radiation may come from a machine outside the body (external-beam radiation therapy), or it may come from radioactive material placed in the body near cancer cells (internal radiation therapy).

Radiation therapy can be used to treat many cancers, alone or in combination with other treatments. It can be used:

-To treat cancer and attempt to prevent recurrence by eliminating tumor.

-As a palliative treatment when eliminating tumor is not possible. (Palliative radiation therapy is intended to relieve pain and other symptoms by reducing the tumor.)

-Before surgery to help reduce the tumor.

-After surgery to treat any remaining cancer cells.

-In combination with chemotherapy treatment.

**Radiosurgery**

Also called radiation surgery. A type of external radiation therapy that uses special equipment or a linac, to pose the patient and give precisely 1-5 large doses of radiation to the tumor. It was first used to treat brain tumors and other brain disorders that could not be treated by regular surgery.

**Question 3**

**Radiation protection during the exploitation of ionizing radiation sources**

**Radiation protection**, sometimes known as radiological protection, is the science and practice of protecting people and the environment from the harmful effects of ionizing radiation.

Fundamentals for radiation protection are the reduction of expected dose and the measurement of human dose uptake.

**Protection groups**

There are the following groups of Radiation protection:

* protection of workers,
* medical radiation protection,
* protection of individual members of the public, and of the population as a whole.

**Factors in dose uptake**

There are three factors that control the amount, or dose of radiation received from a source. Radiation exposure can be managed by a combination of these factors:

**Time**: Reducing the time of an exposure reduces the effective dose proportionally. An example of reducing radiation doses by reducing the time of exposures might be improving operator training.

**Distance:** Increasing distance reduces dose due to the inverse square law, for example by using instruments to handle a source of radiation.

**Shielding:** The term 'biological shield' refers to a mass of absorbing material placed around a radioactive source, to reduce the radiation to a level safe for humans. Hence, shielding strength or "thickness" is conventionally measured in units of g/cm2. The radiation that manages to get through falls exponentially with the thickness of the shield. In x-ray facilities, walls surrounding the room with the x-ray generator may contain lead sheets, or the plaster may contain barium sulfate. Operators view the target through a leaded glass screen, or if they must remain in the same room as the target, wear lead aprons. Almost any material can act as a shield from gamma or x-rays if used in sufficient amounts.

Practical radiation protection tends to be a combination of juggling three factors to identify the most cost effective solution.

 **To reduce doses from intake of radioactive substances, the following basic countermeasures can be considered**:

1. shortening time of exposure to contaminants;

2. preventing surface contamination (The tightness of the equipment);

3. preventing inhalation of radioactive materials in air (An efficient ventilation system and use of respiratory protective equipment);

4. preventing ingestion of contaminated foodstuffs and drinking water.

5. Radiation control and medical monitoring.

**Question 4**

**Radiation control and medical monitoring**

• Control of radiation dose at the working places with ionizing radiation sources.

• Control of the operating conditions and the effectiveness of radiation protection equipment.

• Individual dose control of staff.

• Individual dose control of persons periodically involved in X-ray procedures (surgeons, anesthesiologists and others.).

• Dose control of patients.

**Absorbed dose** is a physical dose quantity D representing the mean energy imparted to matter per unit mass by ionizing radiation. In the SI system of units, the unit of measure is joules per kilogram, and its special name is gray (Gy). Absorbed dose is used in the calculation of dose uptake in living tissue in both Radiation Protection and Radiology .

**Equivalent dose** is a physical quantity of absorbed dose, that takes into account the biological effectiveness of the radiation, which is dependent on the radiation type and energy.

 The radiation dose quantity **effective dose** is the tissue-weighted sum of the equivalent doses in all specified tissues and organs of the body. It takes into account the type of radiation and the nature of each organ or tissue being irradiated.

The SI unit for effective dose is the sievert (Sv) which is one joule/kilogram (J/kg).

**Question 5**

**Radioactive wastes**

***Radioactive wastes*** are wastes that contain radioactive material. Radioactive wastes are usually by-products of nuclear power generation and other applications of nuclear fission or nuclear technology, such as research and medicine. Radioactive waste is hazardous to most forms of life and the environment, and is regulated by government agencies in order to protect human health and the environment.

Radioactivity naturally decays over time, so radioactive waste has to be isolated and confined in appropriate disposal facilities for a sufficient period of time until it no longer poses a threat. The period of time radioactive waste must be stored for depends on the type of waste and radioactive isotopes. It can range from a few days for very short-lived isotopes to millions of years. Current major approaches to managing radioactive waste have been segregation and storage for short-lived waste, near-surface disposal for low and some intermediate level waste, and deep underground disposal or partitioning / transmutation for the high-level waste.

***Sources of waste***

Radioactive waste comes from a number of sources. The majority of waste originates from the nuclear fuel cycle and nuclear weapons reprocessing. Other sources include medical and industrial wastes, as well as naturally occurring radioactive materials (NORM) that can be concentrated as a result of the processing or consumption of coal, oil and gas, and some minerals.

Radioactive medical waste tends to contain beta particle and gamma ray emitters. It can be divided into two main classes. In diagnostic nuclear medicine a number of short-lived gamma emitters such as technetium-99 (Tc -99 half-life about 6 hours) are used. Many of these can be disposed of by leaving it to decay for a short time before disposal as normal waste. Other isotopes used in medicine, with half-lives in parentheses, include:

Y-90, used for treating lymphoma (2.7 days)

I-131, used for thyroid function tests and for treating thyroid cancer (8.0 days)

Sr-89, used for treating bone cancer, intravenous injection (52 days)

Ir-192, used for brachytherapy (74 days)

Co-60, used for brachytherapy and external radiotherapy (5.3 years)

Cs-137, used for brachytherapy, external radiotherapy (30 years)

You should watch a film about use of ionizing radiation in medicine and answer questions. https://drive.google.com/open?id=1cJbAZyk3YvrnmlahUjTIl5WZ59BFFO4S

1. Write down what method of radiation diagnostics was used in the first clinical case.

2. Write what treatment method was used in the second clinical case.

Write a conclusion in your notebook and send for verification in the information system.