EBreast II

Principles of Radiation Protection in Radiotherapy

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INTRODUCTION

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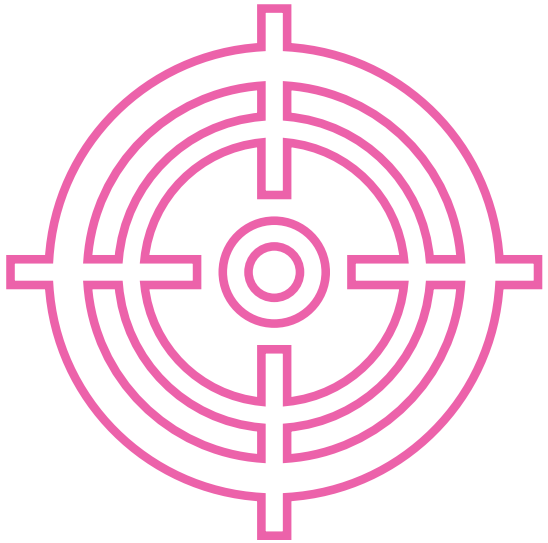

In radiotherapy radiation is deliberately used on patients to kill cancer cells.

Radiation also affect healthy tissues, and damage to healthy cells can cause side effects.

- Aim of radiotherapy is to deliver as much dose as possible to the cancer cells while minimizing the dose to healthy tissues.

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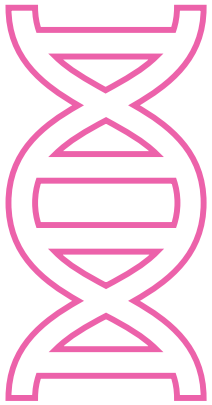

Ionizing radiation has high enough energy to affect the atoms in living cells and thereby damage their DNA.

- If the damage is not repaired correctly, a cell may die or eventually become cancerous. (1.)

INTRODUCTION

Harmful effects can be divided in to two types (2):

Deterministic effects

- Harmful tissue reactions (radiotherapy side effects such as skin irritation).
- Only appear if the dose exceeds a threshold value.
- Due to the killing/malfunction of cells.

Stochastic effects

- Cancer or heritable effects.
- Have no threshold value.
- Can be observed as a statistically detectable increase in the incidences of these effects occurring long after exposure.

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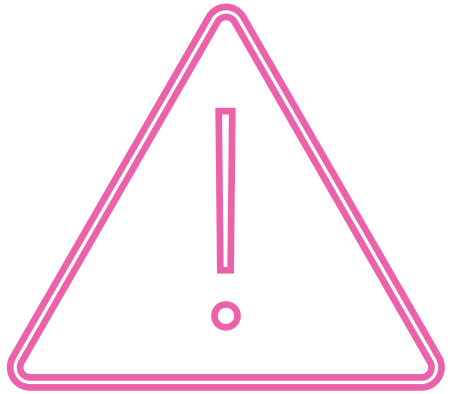

It is generally assumed that even very small doses of ionizing radiation can potentially be harmful and therefore persons must be protected from ionizing radiation at all dose levels.

Radiation protection aims primarily to protect people from harmful effects of exposure to ionizing radiation.

Its safety objectives are to manage and control exposures to ionising radiation so that

- deterministic effects are prevented
- the risks of stochastic effects are reduced to the extent reasonably achievable. (2.)

RADIATION PROTECTION

RADIATION PROTECTION

The principal components of the system of radiation protection (2):

- A characterisation of the possible situations where radiation exposure may occur
- A classification of the types of exposure
- An identification of the exposed individuals
- A categorisation of the types of assessment, namely source-related and individual-related
- A precise formulation of the principles of protection: justification, optimisation, and application of dose limits
- A description of the levels of individual doses that require protective action or assessment
- A delineation of the conditions for the safety of radiation sources, including their security and the requirements for emergency preparedness and response

RADIATION PROTECTION

A characterisation of the possible situations where radiation exposure may occur

1) Planned exposure situations
    - Situations where radiation protection can be planned in advance, and exposures can be reasonably predicted
        - E.g. receiving radiotherapy

2) Existing exposure situations
    - Situations that already exist when a decision on control has to be taken
        - E.g. radon gas at home

3) Emergency exposure situations
    - Unexpected situations that may require urgent protective actions
        - E.g. incidents and accidents in radiotherapy (2.)

RADIATION PROTECTION

A classification of the types of exposure

1) Medical exposure
   - Exposure of patients as part of their radiotherapy treatment.

2) Occupational exposure
   - Exposure of workers incurred in the course of their work.

3) Public exposure
   - Exposure of members of the public other than occupational and medical exposures.
     - E.g. people in the waiting room. (2.)

RADIATION PROTECTION

An identification of the exposed individuals

- Radiation protection must take into account and identify not only the medical (the patient), but also occupational (the staff) and public exposure.

- A given individual may be exposed as a worker, and/or as a member of the public, and/or as a patient. (2.)

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RADIATION PROTECTION

A categorisation of the types of assessment, namely source-related and individual-related

- Source-related restrictions
  - For planned exposure situations, the source-related restriction to the dose that individuals may incur is the dose constraint.
  - For potential exposures, the corresponding concept is the risk constraint.
  - For emergency and existing exposure situations, the source-related restriction is the reference level.

- Individual-related restrictions
  - In the specific case of planned exposure situations, separate restrictions on the sums of the occupational doses and on the sums of the public doses are required.
  - These individual-related restrictions are called dose limits. (2.)

RADIATION PROTECTION

A precise formulation of the principles of protection: justification, optimisation, and application of dose limits

- Justification
  - Benefit of a practice must offset the radiation detriment
    - Radiotherapy should yield sufficient benefit to the exposed individual to outweigh the radiation detriment it causes.
- Optimization
  - Exposures and likelihood of exposure should be kept as low as reasonably achievable
    - Radiotherapy should be optimized so that the correct dose is given to the target volume and the dose to healthy tissues is limited to acceptable levels.
- Dose limits to individuals
  - The total dose to any individual from regulated sources in planned exposure situations other than medical exposure of patients should not exceed the appropriate dose limits. (2.)

RADIATION PROTECTION

A description of the levels of individual doses that require protective action or assessment

- Dose constraint and reference level
  - A level of individual dose needs to be defined.
  - The initial intention would be to not exceed, or to remain at, these levels, and the ambition is to reduce all doses to levels that are as low as reasonably possible.
- Dose constraints
  - A dose constraint is a prospective and source-related restriction on the individual dose from a source in planned exposure situations (except in medical exposure of patients), which serves as an upper bound on the predicted dose in the optimisation of protection for that source.
- Dose limits
  - Apply only in planned exposure situations but not to medical exposures of patients.
  - These are regulatory limits for occupational and public exposure which should not be exceeded. (2.)

RADIATION PROTECTION

A delineation of the conditions for the safety of radiation sources, including their security and the requirements for emergency preparedness and response

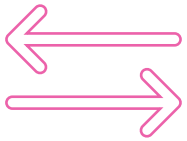
- Safety of radiation sources must be adequately ensured.
- Emergency preparedness must be ensured. (2.)

RADIATION PROTECTION STRATEGIES

Radiation exposure can be limited due by the principles of **time, distancing and shielding**.

Time

- The shorter the exposure time, the lower the dose.
- In radiotherapy only the patient is in the treatment room when radiation is on.



Distance

- Distance is very efficient for radiation protection as the dose falls off in square.
- E.g. big bunkers for radiation equipment.

Shielding

- The treatment room is designed to protect for high energetic photons radiation. The walls contain high density materials and they don’t pass more dose than the law allows. (3.)

SAFETY CULTURE

SAFETY CULTURE

The IAEA (International Atomic Energy Agency) defines a **safety culture** as

> *“the assembly of characteristics and attitudes in organizations and individuals which establishes that, as an overriding priority, protection and safety issues receive the attention warranted by their significance.”* (4.)

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SAFETY CULTURE

- Radiation safety culture is a combination of **knowledge, skills, beliefs, and practices** related to radiation safety and culture.

- A strong radiation safety culture can reduce radiation exposure through the application of the principles of justification, optimization, and dose constraints. It also reduces medical errors, improve diagnosis and treatment, and improve efficiency.

- Establishing a radiation safety culture is more than rules, it is a change in the individual behaviour, the organisations behaviour and professional behaviour. (5.)

SAFETY CULTURE

- IAEA (International Atomic Energy Agency) has identified several indicators of a strong safety culture (5):

Leadership Responsibility	Problem Identification and Resolution	Work process	Effective Safety Communication	Environment for Raising Concerns
Respectful Work Environment	Decision Making	Continuing Learning	Questioning Attitude	Individual Responsibility

SAFETY CULTURE

Leadership Responsibility	Leaders demonstrate a commitment to safety in their decisions and behaviours.
Problem Identification and Resolution	The process of planning and controlling work activities is implemented so that safety is maintained.
Work process	The process of planning and controlling work activities is implemented so that safety is maintained.
Effective Safety Communication	Safety communication is broad and includes facility level communication, job-related communication, worker-level communication, equipment labelling, operating experience, and documentation.
Environment for Raising Concerns	Organisations should focus on achieving and maintaining an environment where employees feel free to raise their concerns directly to their supervisors, as well as ensuring that alternate means of raising and addressing concerns are accessible, credible, and effective. (5.)

SAFETY CULTURE

Respectful Work Environment	Trust and respect permeate the organisation. A high level of trust is established in the organisation, fostered, in part, through timely and accurate communication.
Decision Making	Decisions that support or affect safety are systematic, rigorous, and thorough.
Continuing Learning	Opportunities to learn about ways to ensure safety are sought out and implemented.
Questioning Attitude	Individuals avoid complacency and continuously challenge existing conditions and activities to identify discrepancies that might result in error or inappropriate action.
Individual Responsibility	All individuals take personal responsibility for safety. Responsibility and authority for safety are well defined and clearly understood. (5.)

INTERNATIONAL SAFETY STANDARS

INTERNATIONAL SAFETY STANDARDS

- The IAEA (International Atomic Energy Agency) safety standards reflect an international consensus on what constitutes a high level of safety for protecting people and the environment from harmful effects of ionizing radiation.

- They are based on the knowledge of biological effects on radiation and on principles for protection from undesirable effects.

- The Standards place requirements on those authorized to conduct a practice using radiation, and are based on the presumption that there is a national infrastructure enabling governments to discharge their responsibilities for protection and safety. (1.)

RESPONSIBILITIES

- There is a hierarchy of responsibilities from national governments to regulatory bodies to the organizations responsible for, and the persons engaged in, activities involving radiation exposure. (1.)

The government
is responsible for the adoption within its national legal system of such legislation, regulations, and standards and measures as may be necessary to fulfil all its national and international obligations effectively.

Person or organization responsible for facilities and activities *(e.g. hospital management)*
has the prime responsibility for safety.

Health professionals responsible for delivery of medical exposure
has primary responsibility for protection and safety for patients. Only persons with the appropriate competencies are allowed to take particular roles and responsibilities.

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TAKE A MOMENT AND REFLECT…

1) Why radiation safety must be ensured?

2) Who can be exposed to radiation in radiotherapy departments?

3) Why is safety culture in radiotherapy important?

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Authors

Marttila-Tornio Kaisa

Pieck Myrthe

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OULU UNIVERSITY OF APPLIED SCIENCES

Metropolia
University of Applied Sciences

movetia
Austausch und Mobilität
Echanges et mobilité
Scambi e mobilità
Exchange and mobility

TARTU TERVISHOIU KÕRGKOOL
TARTU HEALTH CARE COLLEGE

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Haukeland University Hospital

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