RADP 215 – Radiation Protection Assignment: Radiation Risk Topic:Stochastic Effects



Student name: Huilin Sun(Ulrica)

Weight : 30%

Introduction

Radiation protection is an essential part of medical imaging, aiming to minimize unnecessary exposure to both patients and healthcare professionals. One of the key concepts in radiation biology is understanding the difference between deterministic effects and stochastic effects of radiation. Unlike deterministic effects, which have a threshold dose and increase in severity with higher exposure, stochastic effects occur randomly and are based on probability rather than severity. In this assignment, I will explain what stochastic effects are, how they work at the cellular and molecular levels, and why understanding them is important for medical imaging technologists in protecting both patients and staff.



Definition of Stochastic Effects

Stochastic effects are radiation-induced outcomes that occur by chance and do not have a threshold dose. This means that even the smallest dose of ionizing radiation carries some probability of causing a stochastic effect. The key characteristic is that while the likelihood of occurrence increases with dose, the severity of the effect does not.

The two main stochastic effects of radiation exposure are:

1. **Cancer induction** – prolonged or repeated exposure to radiation can increase the risk of cancers such as leukemia, thyroid cancer, breast cancer, and lung cancer.

2. **Genetic mutations** – radiation can cause damage to the DNA within germ cells, potentially leading to heritable conditions in future generations.

Mechanism of Stochastic Effects

At the biological level, stochastic effects are linked to DNA damage. When ionizing radiation interacts with human tissue, it may cause direct breaks in DNA strands or indirect damage through the production of free radicals. Most DNA damage is repaired naturally by the body, but in some cases, incorrect repair or unrepaired damage can lead to mutations.

If such a mutation occurs in a somatic cell, it may lead to uncontrolled cell division and eventually cancer. If the mutation occurs in a germ cell, it may be passed on to future offspring as a genetic defect. Importantly, these effects can happen even with very low doses of radiation, which is why the “no safe dose” concept is often applied when discussing stochastic risks.

Examples in Medical Imaging Practice

In diagnostic imaging, radiation doses are typically low, but repeated exposures over time can accumulate. For example, patients undergoing multiple CT scans for chronic conditions have a higher cumulative risk of developing stochastic effects compared to someone who only receives one chest X-ray.

Another scenario involves medical staff, such as radiologic technologists. Even though protective measures (lead aprons, thyroid shields, and proper positioning) are used, repeated occupational exposure over a career increases the probability of stochastic effects. This highlights why radiation safety protocols, including ALARA (As Low As Reasonably Achievable), are essential.

Examples in Medical Imaging Practice

- In diagnostic imaging, radiation doses are typically low, but repeated exposures over time can accumulate. For example, patients undergoing multiple CT scans for chronic conditions have a higher cumulative risk of developing stochastic effects compared to someone who only receives one chest X-ray.

- Another scenario involves medical staff, such as radiologic technologists. Even though protective measures (lead aprons, thyroid shields, and proper positioning) are used, repeated occupational exposure over a career increases the probability of stochastic effects. This highlights why radiation safety protocols, including ALARA (As Low As Reasonably Achievable), are essential.

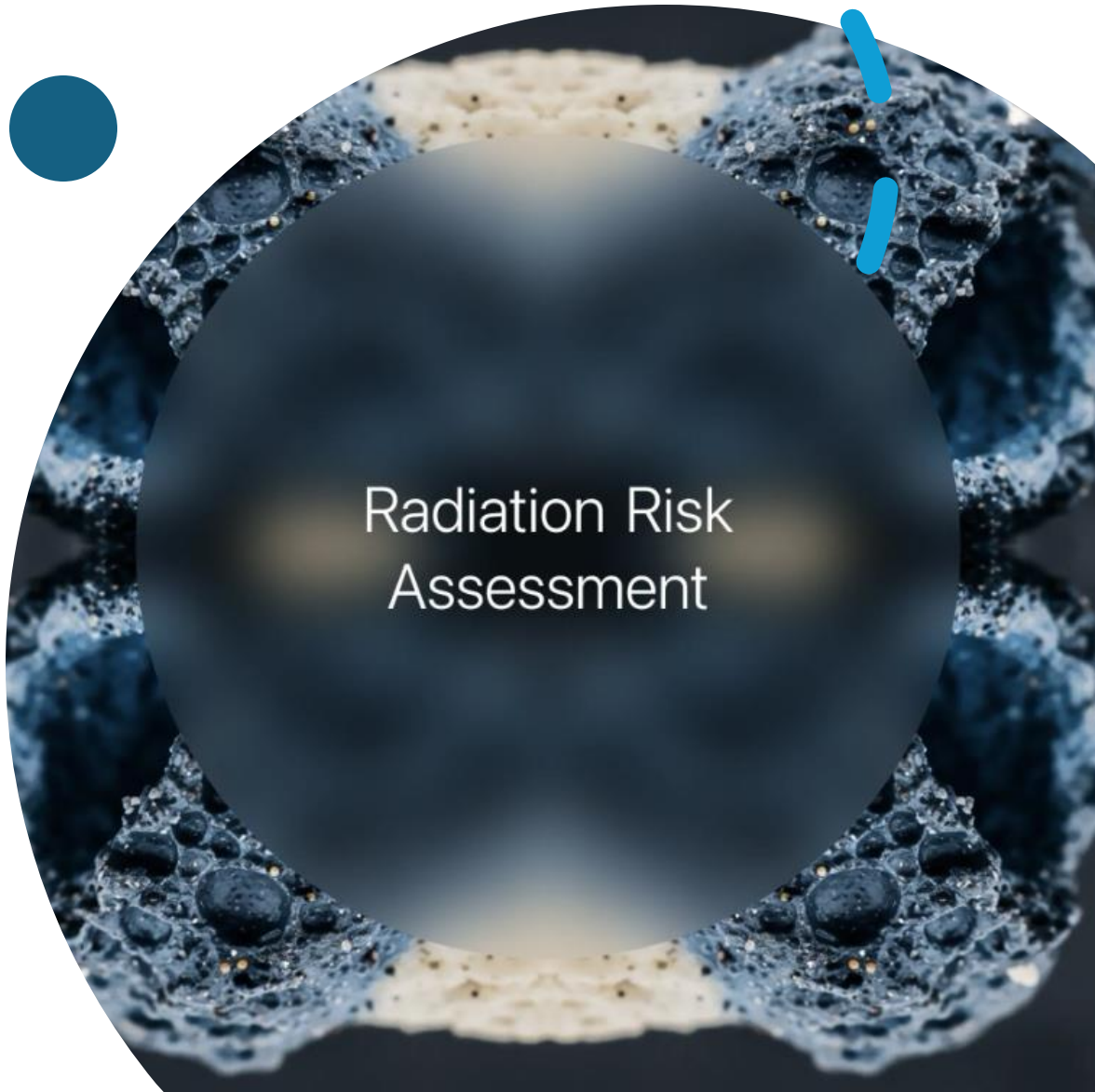
Radiation Protection and Risk Estimates

Understanding stochastic effects emphasizes the importance of minimizing patient and worker exposure. The Linear No-Threshold (LNT) model is often used to estimate risk, suggesting that the probability of cancer increases linearly with dose, with no safe lower limit.

For example:

- A chest X-ray may deliver a dose of around 0.1 mSv. While the risk of developing cancer from a single X-ray is extremely small, the principle of cumulative exposure means risks increase with more imaging procedures.
- CT scans, which may deliver doses between 5–20 mSv, carry a higher probability of contributing to stochastic effects, especially in pediatric patients who are more radiosensitive.

- By applying justification (only performing exams when clinically necessary), optimization (using the lowest dose possible for diagnostic quality), and protection principles, technologists play a direct role in reducing stochastic risks.



Why It Matters for Medical Imaging Technologists

For future medical imaging technologists like myself, understanding stochastic effects is critical for several reasons:

- **Patient Safety** – Being aware of stochastic risks ensures that I always apply ALARA principles and justify every procedure.
- **Professional Safety** – Protecting myself and colleagues from occupational exposure is just as important as protecting patients.
- **Communication with Patients** – Patients may have concerns about radiation exposure. Being able to explain the concept of stochastic risk in clear, reassuring terms builds trust and confidence in the imaging process.

- Ultimately, recognizing that every exposure carries some probability of risk keeps me vigilant in applying radiation protection principles consistently.

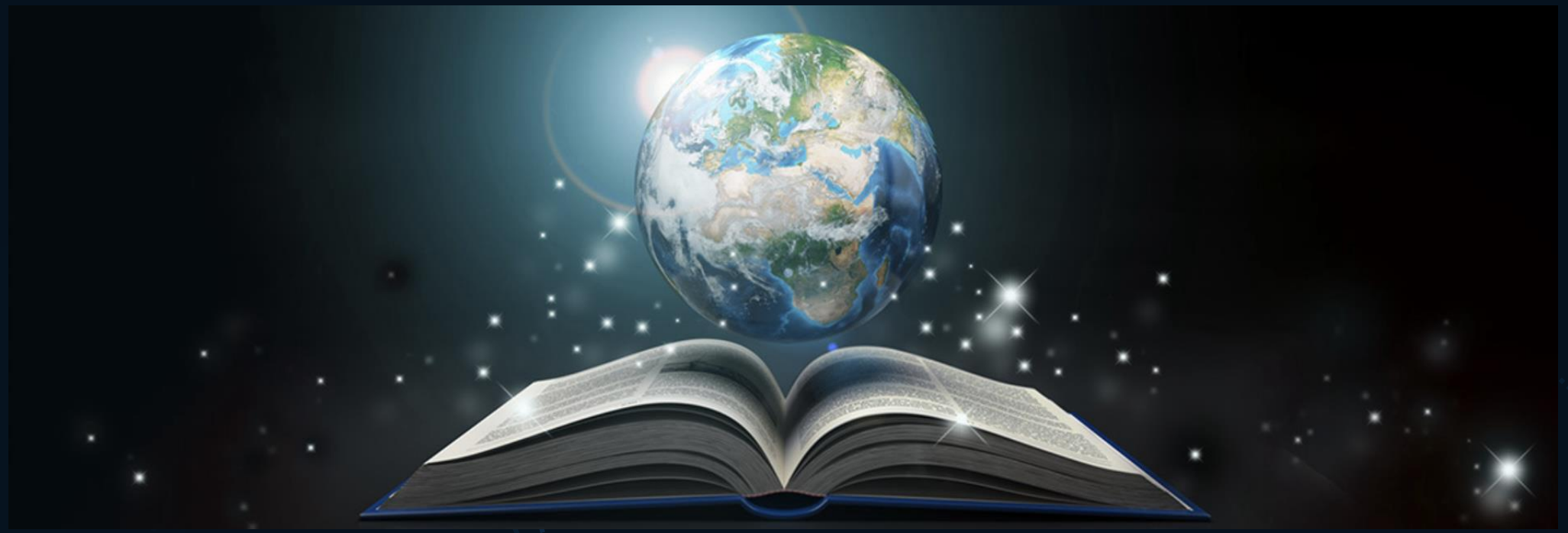


Stochastic effects represent the unpredictable, probabilistic side of radiation biology. Unlike deterministic effects, they have no threshold and are concerned with the chance of occurrence rather than severity.

Cancer induction and genetic mutations are the two most significant stochastic effects, and while the risk from individual diagnostic exams is very small, cumulative exposure can make the probability meaningful over time.

For medical imaging technologists, this knowledge reinforces the responsibility to minimize unnecessary exposure for both patients and staff. By adhering to ALARA, justifying imaging procedures, and using protective equipment properly, we can ensure that the benefits of diagnostic imaging outweigh the potential risks of stochastic effects.





References

- Bushong, S. C. (2021). Radiologic Science for Technologists. Elsevier
- Hall, E. J., & Giaccia, A. J. (2018). Radiobiology for the Radiologist. Wolters Kluwer
- ICRP (2007). The 2007 Recommendations of the International Commission on Radiological Protection


Thank you