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A short Review of the ALARA Principle in Radiation Protection

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Short Communication

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Abstract

Any activity involving radiation should be planned and conducted in such a way that the exposures to individuals are optimally low, taking into consideration the economic and cost aspects. This principle of optimization is called ALARA. ALARA stands for "As Low as Reasonably Achievable". The ALARA principle states that the radiation exposures should be limited to a minimum level since the Ionizing radiation may produce biological effects in the exposed person.

Background of ALARA Concept: The introduction of ALARA was a great philosophical change, as instead of working up to the permissible exposure limits, the idea was to keep exposures to levels as far below the limits as could reasonably be done, considering economic and technical factors. The linear-no-threshold (LNT) model, labeled is the basis of the ALARA protocol; if even small doses lead to slight increases in the risk of cancer than doses should be kept as low as possible. The concept of ALARA was first introduced in 1954 in the National Council on Radiation Protection & Measurements (NCRP) Report, and later in International Commission on Radiological Protection (ICRP) Publication 1 where it was initially called ALAP, the acronym for As Low As Practicable (ICRP 1959b). As per Atomic Energy Regulatory Board (AERB), Govt of India, all radiation work should be carried out in a preplanned and controlled manner so that the exposure to the workers and persons in and near sites of radiation use is kept as low as reasonably achievable (ALARA) and does not exceed the recommended limits. Suitable control measures shall be employed to minimize radiation exposure so that maximum benefits are derived with minimum radiological risk.

Discussion: The ALARA principle appears simple but is often misinterpreted and inappropriately applied in radiation protection. It is often interpreted as "as low as possible" without taking into consideration the balancing factors. Considering radiation shielding requirements as an example excessive unnecessary shielding with materials such as lead, steel, or concrete is a waste of global resources. This in turn can cause other damages such as chemical harm and pollution to the environment, which have proven damages to human health. It is more meaningful to make use of the wasted resources for service improvements, such as reducing the charges to patients, investing in better medical technologies, and training of staff.

Conclusion: The aims of radiation protection are (i) to avoid the occurrence of deterministic effects and (ii) to limit the risk of stochastic effects. ALARA protocol has successfully limited the exposure of radiation workers to impressively low levels of dose around 1 mSv. Since significant costs are incurred to comply with ALARA and the validity of the LNT model is unclear below doses of 100 mSv, more research on the health effects of low radiation doses is necessary before alternatives to ALARA can become viable.

Keywords: ALARA; Radiation; Radiological Protection; Radiological Risk

Abbreviations: LNT: Linear-No-Threshold; NCRP: National Council on Radiation Protection; ICRP: International Commission on Radiological Protection; AERB: Atomic Energy Regulatory Board; ICRU: International Commission on Radiation Units; PPE: Personal Protective Equipment.

Introduction

Ionizing radiations are much widespread in industry, medicine and for research purposes [1]. Any activity involving radiation should be planned and conducted in such a way that the exposures to individuals are optimally low, taking into consideration the economic and cost aspects. This principle of optimization is called ALARA. ALARA stands for "As Low as Reasonably Achievable". The ALARA principle states that the radiation exposures should be limited to a minimum level since the Ionizing radiation may produce biological effects in the exposed person. There shall be no intentional exposure to radiation unless there are benefits to either the individual or society [2].

Principle and Background of ALARA Concept

The introduction of ALARA was a great philosophical change, as instead of working up to the permissible exposure limits, the idea was to keep exposures to levels as far below the limits as could reasonably be done, considering economic and technical factors. Research done by Douple, et al. found a linear association between received dose and cancer risk for levels above 100 mSv by estimating received dose based on distance from the hypocenter by following the survivors for many years after the atomic bombing. Below 100 mSv, uncertainties in the actual absorbed dose become quite significant, and the contribution of risk from spontaneous (i.e., from causes other than radiation exposure) cancer becomes a significant component. Various models of the relationship between dose and response have therefore been proposed (Figure 1).

The linear-no-threshold (LNT) model, labeled "A" in Fig 1. is the model that is the basis of the ALARA protocol; if even small doses lead to slight increases in the risk of cancer than doses should be kept as low as possible. The rationale behind sub-linear response models ("B") is that biological repair processes minimize or eliminate cancer risk at low dosages. The other model "C" propose a threshold below which low doses do not lead to an increased risk of cancer. Due to the lack of clear data and the magnitude of the risks involved, ALARA is a sensible choice as a conservative safety protocol, at least until more study illuminates the true harm of low doses of radiation to human health [3-7].

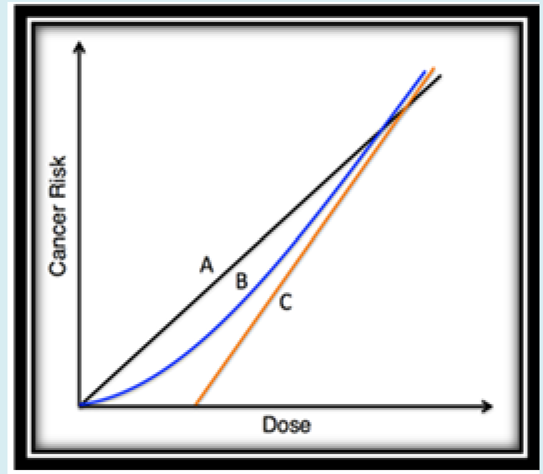

Figure 1: The Linear Non Threshold model (A), which is the basis of the ALARA protocol.
(B) Sub-linear model (C) Threshold model (C) (After USNRC NUREG-0713.)

Recommendation of International Committees on ALARA

The growth of the use of ionizing radiation has necessitated the creation of organizations and standards for developing the scientific and technical basis of the safe application of ionizing radiation [8-10]. The philosophy and objectives of radiation protection described by the International Committees apply to the protection of healthcare personnel, patients, and members of the public.

The International Commission on Radiation Units and Measurements (ICRU) established in 1925, and the International Commission on Radiological Protection (ICRP) established shortly thereafter in 1928 are the core institutions that provide recommendations to the international community on radiation protection. National Council on Radiation Protection & Measurements (NCRP) was chartered by the U.S. Congress in 1964 [11,12]. The NCRP and ICRP have adopted an approach in which the maximum exposure limits for radiation workers are set based on radiation risk estimates. Then the limits for the general public are set to be a fraction of those accepted for radiation workers.

For the protection of non-occupationally exposed individuals and members of the public against stochastic effects in contexts of continuous (or frequent) radiation exposure, an annual effective dose of 1 mSv is recommended by the NCRP and also by the ICRP [13-15]. The concept of ALARA was first introduced in 1954 in the NCRP Report, and later in ICRP Publication 1 where it was initially called ALAP, the acronym for As Low as Practicable (ICRP 1959b).

AERB Recommendation on ALARA Principle

As per Atomic Energy Regulatory Board (AERB), Govt of India, all radiation work should be carried out in a preplanned and controlled manner so that the exposure to the workers and persons in and near sites of radiation use is kept as low as reasonably achievable (ALARA) and does not exceed the recommended limits. The doses to the occupational workers shall be kept As Low as Reasonably Achievable (ALARA) and doses to patients shall be optimized. Suitable control measures shall be employed to minimize radiation exposure so that maximum benefits are derived with minimum radiological risk.

This should be possible and achievable while taking economic and technical factors into account. Both technical and administrative controls are used to prevent injury and reduce the risk of radiation exposure. The controls include engineering, e.g., shielding built into walls, personal protective equipment (PPE) such as lead aprons, and administrative controls, such as monitoring a patient at the completion of a procedure, etc. Instead of working up to the permissible exposure limits, the idea was to keep exposures as far below the limits. Medical health physicists are often challenged to maximize the protection of personnel while minimizing the cost of resources necessary to keep radiation doses ALARA.

Safety culture should be inculcated that governs attitudes and behavior concerning the protection and safety of all individuals and organizations dealing with sources of radiation; Protection and safety should be ensured by sound management and good engineering, quality assurance, training and qualification of personnel, comprehensive safety assessments, and attention to lessons learned from experience and research. ALARA has now expanded into a full-blown program and all tasks in the Radiation practices are assigned with an ALARA review. Personnel exposure records are kept and compared to previous years for evaluation in terms of ALARA. ALARA is also used to evaluate all physical measures, such as protective shielding, etc.

Misinterpretation of ALARA Principle

The ALARA principle appears simple but is often misinterpreted and inappropriately applied in radiation Protection. It is often interpreted as "as low as possible" without taking into consideration the balancing factors. Considering radiation shielding requirements as an example, the regulators in some countries set very stringent legislative requirements based on instantaneous dose rates without taking into consideration workload, occupancy, and use factors. This results in the demand for excessive shielding in their radiological facilities, even for infrequently used equipment. Such an approach usually cannot make any significant difference in the overall radiation safety of the facility. On the contrary, excessive unnecessary shielding with materials such as lead, steel, or concrete is a waste of global resources. This in turn can cause other damages such as chemical harm and pollution to the environment, which have proven damages to human health. It is more meaningful to make use of the wasted resources for service improvements, such as reducing the charges to patients, investing in better medical technologies, and training of staff.

Summary & Conclusion

The aims of radiation protection are (i) to avoid the occurrence of deterministic effects and (ii) to limit the risk of stochastic effects. All radiation work should be carried out in a preplanned and controlled manner so that the exposure to the workers and persons in and near sites of radiation use is kept as low as reasonably achievable (ALARA) and does not exceed the recommended limits. ALARA protocol has successfully limited the exposure of radiation workers to impressively low levels of doses around 1 mSv. Since significant costs are incurred to comply with ALARA and the validity of the LNT model is unclear below doses of 100 mSv, more research on the health effects of low radiation doses is necessary before alternatives to ALARA can become viable.

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