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# Radiation Safety Guide for Nuclear Medicine Professionals

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# Radiation Safety Guide for Nuclear Medicine Professionals

 Springer

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## Preface

The origin of this book goes back to our YouTube videos, which are an effort to bring nuclear medicine out of the books, journals and classrooms and allow learning for everyone from anywhere. Along with conventional topics, we also cover practical topics that are not taught anywhere but are faced in the day-to-day life of nuclear medicine professionals. From this book medium, we cordially invite everyone from the nuclear medicine fraternity to come forward and share their knowledge to make nuclear medicine learnings easy and accessible. Since, I had already authored one book with Springer, the editorial director Dr Naren Aggarwal proposed to compile the content of videos in the form of a book which they wish to publish. However, I was unsure about how the book would shape with staggered topics. One name that came to my mind was Dr Pankaj Tandon from Atomic Energy Regulatory Board, who probably could be a co-author and provide some more topics to make a sensible book. When contacted, he said he was already working on a book and looking for a publisher. We collaborated and moved forward by adding two more co-authors for their expertise, and this book is in front of you.

The book contains years of experience from all the four authors and can work as a reference book for working nuclear medicine professionals and a textbook for Radiological Safety Officer (RSO) examination appearing students. We tried to cover all the aspects related to Radiation Safety, starting from basic radiation physics, radiation biology, quality control, design of facilities, dosimetry, mechanism of radiation detectors, emergency preparedness, transport of radioactive materials, and various regulations applied to nuclear medicine facilities and finally, the short questions for RSO examination appearing students. In many places, regulatory documents say 'contact RSO for further management', whereas there is no proper reference to which RSOs can refer and act in various radiological situations. Hopefully, this book would be helpful in all such situations.

From Chapters 1 to 5, the basics of radiation physics, radiation quantities and units, the interaction of radiation with matter, principles of radiation protection, biological considerations, dose limits and their significance, radiation hazards and their control, exposure, exposure rate, exposure rate constant, half-value layer, tenth-value layer, the build-up factor, effective half-life, the annual limit of intake (ALI), derived air concentration (DAC) and surface contamination limits have been covered.

Chapter 6 explains occupational and public exposures, types and categories of exposure, identification of exposed individuals, death of patients administered with radiopharmaceuticals, possibilities of exposure in nuclear medicine, elimination of radionuclides from internal routes, the principle behind the estimation of effective dose, among others. Chapter 7 speaks about the biological bases of radiation protection, radiation effects at the cellular level, relative biological effectiveness, deterministic and stochastic effects, acute radiation syndrome and damage to individual organs. Chapters 8, 9 and 10 explain the planning and design of nuclear medicine facilities, high-dose therapy facilities and cyclotrons, respectively. They include site selection, layout and area requirement, equipment and accessories, staff, shielding requirements and calculations for SPECT-CT and PET-CT facilities, and calculation of ceiling thickness above the PET-CT. The chapter on high-dose therapy provides details of the isolation room, shielding requirements, delay and decay tank specifications, and a discussion on the alpha therapy facility. The cyclotron chapter additionally provides shielding calculations for unshielded and self-shielded cyclotrons. Chapter 11 explains personnel monitoring, radiation protection survey, objectives and benefits of personnel monitoring, dose limits for planned and emergency exposure situations, dose limit for medical exposure of patients, comforters, carers, and volunteers of biomedical research, personnel monitoring during pregnancy, TLD overexposure investigation, situations that do not warrant personnel monitoring and the survey of nuclear medicine facility.

Chapters 12, 13 and 14 explain radiation safety consideration in nuclear medicine, medical cyclotron and radiopharmaceutical preparation. Radiation safety in nuclear medicine says about various radioisotopes used in nuclear medicine therapy, pre- and post-therapy precautions, radiation safety of nursing staff and visitors, discharge criteria for the patients in the isolation ward, optimization of radiation doses to non-target tissues and a brief about handling emergency procedures. The chapter on medical cyclotron discusses the surveillance programme, the safety of pregnant radiation workers, handling, storage, and disposal of radioactive waste, and record keeping. Chapter 14 provides detailed insight about dose calibrators, including choices and pressure of gases, calibration factors, energy response curve, probability of photoelectric and Compton effects, sources of error and quality control. The chapter discusses radiopharmaceutical doses for adults, children and obese patients with the methods to modify them, medical events or misadministration, and the control of radiation hazards in radiopharmacy.

Chapter 15 explains the working mechanism of radiation detectors and includes basic principles of radiation detector, their characteristics, types of radiation detectors, the working mechanism of gas-filled detectors, voltage-response curve, analogue pocket dosimeters, digital pocket dosimeters, gun monitor, proportional counters, Geiger-Muller (GM) counters, scintillation detectors, CT detectors, semiconductor detectors and thermo-luminescent dosimeters (TLDs).

Chapter 16 talks about planar and single-photon emission computed (SPECT) gamma camera quality control with National Electrical

Manufacturers Association (NEMA) standards and other widely accepted protocols. Many factors which contribute to the final image quality, such as uniformity, resolutions, collimation, count rate capability and the hard copy devices, have been explained. For tomographic imaging, an additional set of parameters that influence clinical images, e.g. centre of rotation, gantry and collimator hole alignment, rotational stability of detector heads and integrity of the reconstruction algorithms, have been explained. Chapter 17 shows the quality control procedures for positron emission tomography (PET) machines and includes acceptance testing and routine quality control procedures. All minor details such as instruments needed, activity needed, and step-by-step procedure with illustrative images are provided so that nuclear medicine physicists can refer to this book and do the quality control effectively on their own.

Chapter 18 enlightens about the management of radiation emergencies and their preparedness. Since the best management of radiation emergencies is to prevent the occurrence, the chapter starts with prevention first and then discusses the complete set of situations such as spillage of radiopharmaceuticals, the incidental release of radioactive dust, fumes and gases, medical events (misadministration), medical emergencies including death involving patients administered with therapeutic doses of radiopharmaceuticals, unauthorized access to nuclear medicine facility, loss or theft of radioactive source, fire, bomb threat, natural disasters and accident of the vehicle carrying radioactive material.

Chapters 19 and 20 discuss nuclear medicine and CT dose assessments considering practical dosimetry situations. The Nuclear Medicine Dose Assessment chapter explains the need, ALARA and AHASA concepts, the term 'absorbed dose', its units, the formula for calculating absorbed dose and its components, resources for raw data, the concept of equivalent dose and effective dose and their uses, various systems of dose assessment including Medical Internal Radiation Dosimetry (MIRD), the International Commission on Radiation Protection (ICRP), the Radiation Dose Assessment Resource (RADAR) methods, free resources for dose assessment of diagnostic nuclear medicine and a discussion on practical therapeutic nuclear medicine dose assessment. Chapter 20 talks about CT dose assessment and includes the principle of CT machine functioning, the various terms used in CT dose assessment, estimation of CT doses, calculation of effective doses from system-generated CT dose reports with practical examples, diagnostic reference levels (DRLs) and achievable doses.

A large number of applications of radioactive material (RAM) necessitate its transport from one place to another. Chapter 21 explains rules associated with the transport of RAM, terms used in transportation, type of packages and their requirements, category of packages, transport index, marking, labelling, placarding, etc. Chapter 22 explains the legislation and role of national regulatory authorities in Nuclear Medicine. It covers the Atomic Energy Act, various rules issued under this act, AERB safety directives, the safety code for nuclear medicine facilities and the roles of employer, licensee, the RSO, nuclear medicine physician and nuclear medicine technologist as per terms

used by the AERB. Chapter 23 explains the radioactive waste disposal and safe management of disused sealed radioactive sources. It explains the fundamental principle of radioactive waste management, classification of wastes, collection and disposal, record keeping, management of cadavers containing radionuclides and disposal of disused sources.

Chapter 24 is very helpful to students appearing for the Radiological Safety Officer (RSO) examination. It contains model 250 multiple-choice questions, 100 true-and-false questions, 60 fill-in-the-blank questions and 40 match-the-following questions. Similar questions may be asked in the RSO written examination. But, for viva questions, one needs to go through the many chapters of this book, and if someone uses this book as a preparation tool, it would definitely be useful.

We hope that efforts put in to prepare this manuscript are helpful to the nuclear medicine fraternity and students. All suggestions and comments are welcomed at [nuclearmedicinesolution@gmail.com](mailto:nuclearmedicinesolution@gmail.com).

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Dibya Prakash

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