Radiation biology for medical physicists in radiology

University of Pavia

Abstract

One of the responsibilities of a MPE is to provide advice on the safety of planned and unplanned exposures to patients, staff, and the public from radiological procedures. Safety guidelines have been produced for this purpose, but these have been formulated for the general public and will not generally apply to individual cases requiring consultation. It is important that the MPE has a good understanding of the range of biological harm that may result from exposure, and the scientific basis for estimating the risks. The daily routine is full of exceptional cases, and it is essential that the MPE can contribute from the basis of a deeper knowledge of the risks to individuals than is provided by routine radiation protection training. The quality of advice and counselling will benefit from an understanding of such topics as the special risks from paediatric exposures or exposure during pregnancy, all aspects of the risks during interventional radiology, and the implications of radiation quality effects of the low-energy x-rays used in mammography. The MPE should be familiar with the underlying science and research basis from which risk assessments are derived.

Furthermore, the MPE has an important role in the management and provision of advice and counselling on the consequences of unplanned radiation exposure situations which may occur in radiological applications. The rules of radiation protection which provide guidance for routine exposures are of limited use in such unplanned situations. Decision-making in unplanned exposure situations requires, in addition to sound physical dosimetry including detailed anatomical dose distribution, a good understanding of the radiobiological processes which lead to the different potential health impairment of the affected persons. These potential health effects to be considered range from heritable diseases in the progeny of the affected persons, developmental injury of the embryo and fetus in utero, to radiation-induced cancer and various early and late occurring non-cancer diseases such as those in the cardiovascular system, in the eyes or the central nervous system. All those potential health effects of un-planned radiation exposures are subject to strong influence of age, sex, dose rate, and anatomical dose distribution, all of which have to be taken into account in the estimation of radiation risk in the individual person.

This course will provide a thorough understanding of the biological response of humans to radiation exposure, as well as the radiobiological basis for estimating subsequent risks. It is divided into an online e-learning component and a 5-day face-to-face component.

Online module

This is a prerequisite for the face-to-face course, and will provide an introduction to the radiobiological features of radiation effects on humans, their dependence on organ dose, age, sex, their latency, their clinical features and diagnostic and prognostic criteria and their impact on the quality of life.

Face-to-face module

The one-week (5 days) face-to-face learning will concentrate on specific exposure scenarios and specific potential health effects. The main topics will be:

Principles of radiobiology and radiation biophysics: fundamental principles of radiobiology and of radiation biophysics (from physical interactions, to initial biological damage and its time evolution); repair processes, chromosome aberration formation, cell inactivation, perturbation of intra- and inter-cellular signalling, “non-targeted” effects (bystander, genomic instability, adaptive response, etc.)

Radiobiological mechanisms of early and late radiation injury in human tissues and organs: in particular bone marrow and skin, radiation syndromes; principles of human radiation genetics and genetic counselling after exposure; principles of radiation effects in the developing embryo and foetus, counselling pregnant women.

Principles of radiation epidemiology: radiation-induced cancer; results of epidemiological and clinical follow-up studies; risk dependence on dose, dose-rate, age sex, critical organs; radiobiological mechanisms of radiation carcinogenesis, stochastic and deterministic mechanisms.

Non-cancer effects of low dose radiation exposure: results of epidemiological and clinical studies. Critical organs: heart, eyes, central nervous system, immune system: Clinical manifestations. risk dependence on dose, dose-rate, age sex. Radiobiological mechanisms of different non-cancer effects.

Balancing risks in special and relevant medical exposures: How to optimize exposures using radiobiology as a guide.