Radionuclide therapy consists in the selective irradiation of a target tissue, usually malignant, by means of a suitably labeled tumor-seeking molecule or device, specifically located at the tumor site and able to contain the irradiation of normal tissues within a dose limit that will not lead to serious complications. This principle is usually illustrated by the balance between the tumor control probability (TCP) and the normal tissue complication probability (NTCP).

The effect on tumor and normal tissues involved, resulting from irradiation, depends not only on the absorbed dose but also on the specific characteristics of the irradiated tissue and on the modality of dose delivery.

In recent years, with the raising complexity of radionuclide therapies, and the consequent narrowing of the therapeutic window, medical approach is switching from an empirical, fixed-dose method (one fits all) to an individualized, dosimetry-based one.

Radiobiology principles, recently adapted to radionuclide therapy, have a large application in clinical practice and help clarifying, beyond mere dosimetry, the dose-response relationship in tumor as in normal tissues, according to their characteristics (like vascularization, oxygenation, proliferation rate). In this sense, radiobiological models interpret mathematically the success and/or the complication of a given treatment.

Tissues like kidney, bone marrow and liver are usually the dose limiting organs of commonly used therapies, such as \(^{90}\text{Y}\) and \(^{177}\text{Lu}\)-labeled radiopeptides, \(^{131}\text{I}\)-mIBG, \(^{131}\text{I}\)-iodine, and \(^{90}\text{Y}\)-labeled microspheres.

The linear quadratic model (LQM), one of the basilar concepts of radiobiology, has been recently modified to interpret nuclear medicine applications. Absorbed dose and other factors, such as tissue radiosensitivity, dose-rate, fractionation and clinical risk factors affect tissue response and are included in the LQM. Lessons from the LQM indicate that a continuous low dose rate, such as in radionuclide treatments, spares normal tissues more than the tumor. Descending from the LQM, the biological effective dose (BED) concept can help quantifying the biological effect of a treatment on both tumor (efficacy) and normal organs (toxicity). This concept has been largely applied in the interpretation of kidney toxicity from radiopeptide therapy.

Inhomogeneity of the dose distribution lead to the calculation of individual BEDs for each voxel in which the dose could be assumed as uniform, thus converting in the EUBED (equivalent uniform BED distribution). This concept is particularly important in therapies, such as radioimmunotherapy, where the antibody distribution in the tumor tissue shows great variations.

Future directions include a more extensive correlation of radiobiological models with actual clinical data from radionuclide therapies, within a tight and dynamic collaboration between the physician and the physicist.

Further reading:


