Radionuclide dosimetry and dosimetric calculations – what is useful on the internet?

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As we all well know, radiation exposure may be external or internal. The term 'external irradiation' indicates exposure due to radiation originating from a source outside the body and may be whole body or partial body. Internal exposure may involve the whole body or only single organs and depend on the characteristics of the chemical compound containing the radionuclide in question. The effect of ionizing radiation depends not only on the absorbed dose (whose SI unit is the gray (Gy)) but also on the type of radiation. It is therefore necessary to apply a radiation weighting factor. The absorbed dose weighted for the type of radiation is known as the equivalent dose. In addition, different tissues have different sensitivities to radiation and so it is also necessary to apply a tissue weighting factor.

The absorbed dose weighted for the type of radiation as well as for the tissue is termed the effective dose. The SI unit for both the equivalent dose and the effective dose is the sievert (Sv). The term 'occupational exposure' covers exposures to workers incurred in the course of their work. Average annual individual effective doses are of the order of 1-2 mSv. Female nuclear medical technologists who become pregnant might be exposed to levels above the special recommended dose limits if they continue their work for the duration of their pregnancy. Control of occupational exposure is normally evaluated by workplace monitoring and individual monitoring. Workplace monitoring is performed to assess external radiation levels (dose rates) and to assess levels of radioactive contamination. While most dosimetric evaluations are made after exposure, there are circumstances where an assessment during exposure may be required. For certain maintenance procedures, especially in areas of high radiation flux, a direct reading alarm dosimeter is required to warn the worker that a specific dose level has been reached. A dosimeter measures only the dose to the device, which is used as an indication of the dose to the individual. It is important to be aware of the range of uncertainties inherent in the overall dosimetry system. While the measurement by the exposed dosimeter is accurate to within a small percentage error, there are uncertainties in the conversion of this measurement to a body or organ dose. However, for radiological protection purposes, the dosimeter reading can be regarded as an acceptable estimate of the dose actually received. A great many measured overexposures are found to be false and to result from improper use of a personal dosimeter, and if this is confirmed, no further action is required. However, once a dose is assessed to have been received, the occupational health services must be informed. The investigation should include the dose estimates made by all the types of dosimetry available. Depending on the type and level of exposure, the health services may need to perform tests on the worker. In the event of an internal exposure through inhalation, the worker is removed from the workplace to prevent any further uptake of airborne radionuclides. This action will allow more accurate dose estimates from repeated measurements of radionuclide content in the body, an organ or body fluids. High doses may warrant interventional therapy to accelerate the excretion of radionuclides. Such therapeutic measures might include the administration of chelating agents to enhance the excretion of transuranic radionuclides, dialysis for high doses from intakes of tritiated water and pulmonary lavage for some inhaled plutonium compounds. Medical procedures are not without risk and are only to be undertaken when the expected dose that would be averted outweighs the risk associated with the intervention.

Many of these therapeutic procedures would be undertaken only at specialized treatment centres. The occupational physician should be prepared to administer the first dose of chelating agents, stable iodine or absorbents and adsorbents, depending on the specific hazards of the workplace. Normally, doses close to the dose limits do not require any special clinical investigation or therapy, and the role of the occupational health personnel is to counsel the overexposed worker that such an exposure is unlikely to produce adverse health effects. Such an advisory role is undertaken whether or not it is solicited by the worker.

Where the exposure is significantly higher than the dose limits but below the threshold for particular deterministic effects, the role of the occupational physician is to counsel the worker and to determine whether biological dose indicators, such as lymphocyte counts and chromosomal aberration assays, are needed to confirm the dose estimates. A blood sample should be taken by the physician for examination and dose estimation but normally no further action is required.

If the assessed external doses for the whole body or organs are around the threshold for deterministic effects, therapeutic action may need to be undertaken. As a basis for this decision, the overexposed worker needs to be examined clinically and any abnormal findings or symptoms recorded. Haematological examination will need to be undertaken in order to monitor the clinical course of the overexposure. If the Exposure is severe enough to lead to acute radiation syndrome, early transfer to specialized treatment facilities is essential. The occupational

physician will institute the initial investigations and treatment of the early symptoms. Immediate life threatening injuries such as fractures and burns must be treated as a priority before transfer to a specialized centre. The long term clinical management of such highly exposed individuals would normally require the expertise available at specialized clinics.

In nuclear medicine, patients are administered varying quantities of different nuclear medicine tracers to either diagnose or treat disease. For diagnostic cases, the doses are usually low – critical organs may receive of the order of 50-100 mGy (5 to 10 rad), and the effective whole body dose equivalent is considerably lower. In therapy, naturally, the doses are much higher, and cannot be well characterized in the general sense.

On the web site of the European Association of Nuclear Medicine you can easily find very valuable tool for NM technologist everyday work – a dosage calculator. https://www.eanm.org/scientific_info/dosagecard/dosagecard.php?navId=548.

Simply select „weight“ and „pharmaceutical“, press „ok“ and read the field „activity to be administered“.

On the other hand on the http://www.doseinfo-radar.com/RADARHome.html, you may find many useful tools for dose calculation. Some of it will be presented in this Mini Course, such as: Patient release calculations, doses for exposure to radioactive patients or other sources for fixed periods of time as well as doses in mSv received together from radiographic procedures and nuclear medicine scans.