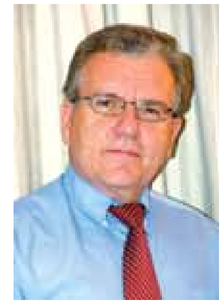
Editor's Page

Ionising Radiation: Not the Big Bad Wolf, but Definitely Not Little Red Riding Hood



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Radiation in general, and ionising radiation in particular, has become an important part of our lives. One kind of ionising radiation is electromagnetic radiation, which includes gamma and X-rays.

Currently, the majority of the radiological examinations in medicine (mammography, CT scans, angiography, radiography, etc.) use X-rays, discovered by Wilhelm Conrad Roentgen—who may fairly be regarded as the "Father of Radiology". As physicians, it would be difficult for us to imagine our everyday practice without the availability of a chest X-ray, a CT scan, or an angiogram, in order to manage and treat our patients optimally. However, there are two sides to every coin: ionising radiation can also be potentially harmful.

The potential unfavourable biological effects of radiation and the magnitude of the damage caused depend mainly on the energy and the type of the radiation, and the characteristics of the absorbing tissue. The *absorbed radiation dose* is the quantity of energy imparted to a unit mass of tissue by ionising radiation. It is expressed in terms of the SI unit gray (1 Gy = 1 joule/kg). The associated biological effect, the *equivalent dose*, depends on the type of radiation and is obtained by multiplying the *absorbed dose* by the respective *radiation weighting factor*.[1] It is expressed in sievert units (Sv). The radiation sensitivity of each organ or tissue is represented by a *tissue-specific weighting factor*.[1] The *effective dose*, also expressed in Sv, is calculated by multiplying the *equivalent dose* by the *tissue-specific weighting factor* and represents the amount of whole-body irradiation that would yield a biological risk equivalent to that of irradiation of only a portion of the body, as occurs during a diagnostic or therapeutic medical procedure.[2]

The biological effects of radiation can be classified as deterministic, or acute effects, and stochastic, or late effects.[3] The severity of a deterministic effect depends upon by how much the radiation dose exceeds a threshold; thus, deterministic effects are preventable. In contrast, for stochastic effects there is no threshold below which radiation cannot cause malignancies and the risk increases linearly with the radiation dose.[3] The biological effects of ionising radiation are the result of direct damage inflicted on the basic unit of life: the cell. Radiation can either directly or indirectly (due to the creation of free radicals) affect the cell's nucleus and chromosomes. If the damage to the cell's DNA is extensive and cannot be repaired, the cell will die. Deterministic effects, such as skin burns, organ failure, or death, occur because of cellular death. As not all cells have the same sensitivity, the radiation dose required to cause a deterministic effect is different for each organ. If the DNA is only partially damaged by radiation, a mutation occurs. Sometimes the cell can repair the mutation without further consequences for the cell and the organ. However, sometimes repair is not possible and the cell survives, but with the particular DNA mutation. These mutations are responsible for the stochastic, or late consequences of radiation and include carcinogenesis, hereditary effects, and effects on an embryo or foetus.

As noted above, deterministic effects are preventable, by keeping radiation doses below the respective threshold. Conversely, the prevention of a stochastic effect is very difficult, since there is no point below which radiation is totally safe. Therefore, users of radiation in medicine must carefully consider the potential drawbacks when ordering a particular examination or therapy. In particular, cardiologists must be extremely cautious, because they are responsible for exposing large segments of the population to ionising radiation. Computed tomography, myocardial perfusion imaging, angiography, electrophysiology, and interventional procedures are now widely applied in daily practice. On the other hand caution should not be allowed to develop into a "radiation phobia" that leads both health providers and patients to avoid valuable medical tools that can effectively provide the best treatment options. The necessary balance is acquired only with training, education, and adequate knowledge of the effective doses and the potential side effects associated with each diagnostic and therapeutic procedure.

However, one must bear in mind two important issues: firstly the aforementioned effective doses are calculated, not measured; and secondly, because of statistical limitations, it is very difficult to estimate the risk to an individual patient or a population undergoing medical examinations or treatments that involve low-dose ionising radiation. Currently, there is no established maximum patient radiation dose that is acceptable. The International Commission on Radiological Protection recommends general dose limits in planned exposure situations.[1] Additionally, a Science Advisory from the American Heart Association emphasises that physicians should only order cardiac imaging studies that expose patients to ionising radiation "after thoughtful consideration of the potential benefit and in keeping with established appropriateness criteria".[2] Furthermore, all procedures involving radiation should be performed under the principle of ALARA (As Low As Reasonably Achievable).[1]

Ionising radiation used with prudence and knowledge is a powerful tool, but used with recklessness and ignorance it is potentially destructive. The fear of radiation may deprive a patient of the proper diagnosis and treatment. A lack of awareness of radiation has the potential to harm both the healthcare provider and the patient. Radiation is not the big bad wolf, but it is also definitely not Little Red Riding Hood. Only education is the key to distinguish fairytales from reality.

References

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