Units In Radiation Medicine

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Introduction

When clinicians read journal articles regarding injury to the human body by ionising radiation there is often confusion regarding the units of measurement. This is compounded by the differences in units used by different countries. In order to avoid this confusion, this article considers the units used by the International Standard (SI) and American sources (1).

SI Units

Gray (Gy): The gray is used to measure a quantity called absorbed dose. This relates to the amount of energy actually absorbed in some material, and is used for any type of radiation and any material. One gray is equal to one joule of energy deposited in one kg of a material. The gray can be used for any type of radiation, but it does not describe the biological effects of the different radiations. Absorbed dose is often expressed in terms of hundredths of a gray, or centi-grays. One gray is equivalent to 100 rads.

Sievert (Sv): The sievert is a unit used to derive a quantity called equivalent dose. This relates the absorbed dose in human tissue to the effective biological damage of the radiation. Not all radiation has the same biological effect, even for the same amount of absorbed dose. Equivalent dose is often expressed in terms of millionths of a sievert, or micro-sievert. To determine equivalent dose (Sv), one multiplies absorbed dose (Gy) by a quality factor (Q) that is unique to the type of incident radiation. One sievert is equivalent to 100 rem (see below for definition).

Becquerel (Bq): The Becquerel is a unit used to measure radioactivity. One Becquerel is that quantity of a radioactive material that will have 1 transformation in one second. Often radioactivity is expressed in larger units like: thousands (kBq), millions (MBq) or even billions (GBq) of a Becquerel. As a result of one Becquerel being equal to one transformation per second there are 3.7 x 10^{10} Bq in one curie.

American Units

Roentgen (R): The roentgen is a unit used to measure a quantity called exposure. This can only be used to describe an amount of gamma and X-rays, and only in air. One roentgen is equal to depositing in dry air enough energy to cause 2.58E^{-4} coulomb per kg. It is a measure of the ionizations of the molecules in a mass of air. The main advantage of this unit is that it is easy to measure directly, but it is limited because it is only for deposition in air, and only for gamma and X-rays.

Rad (radiation absorbed dose): The rad is a unit used to measure a quantity called absorbed dose. This relates to the amount of energy actually absorbed in some material, and is used for any type of radiation and any material. One rad is defined as the absorption of 100 ergs per gram of material. The rad can be used for any type of radiation, but it does not describe the biological effects of the different radiations.

Rem (roentgen equivalent man): The rem is a unit used to derive a quantity called equivalent dose. This relates the absorbed dose in human tissue to the effective biological damage of the radiation. Not all radiation has the same biological effect, even for the same amount of absorbed dose. Equivalent dose is often expressed in terms of thousandths of a rem, or mrem. To determine equivalent dose (rem), one multiplies absorbed dose (rad) by a quality factor (Q) that is unique to the type of incident radiation.

Curie (Ci): The curie is a unit used to measure radioactivity. One curie is that quantity of a radioactive material that will have 37,000,000,000 transformations in one second. Often radioactivity is expressed in smaller units such as thousandths (mCi), millionths (μCi) or even billionths (nCi) of a curie. The relationship between becquerels and curies is: 3.7 x 10^{10} Bq in one curie.

The units quoted most often in biomedical texts are grays, sieverts and rems. One sievert is equivalent to 100 rem. There is no indication that American authors will transfer to the SI system, so for now the two systems continue to co-exist.

LD50: This is the dose needed to kill 50% of an exposed population. The LD50 for ionising radiation is approximately 4.5 Sv (450 rem) if given over a short period of time and no treatment is given (1).

Reference

1. Radiation Related Terms. Idaho State University. [Cited 16/04/04]. Available from URL: http://www.physics.isu.edu/radinf/terms.htm

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