UK Health Security Agency

Radiation Chemical and Environmental Hazards Directorate

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Dosimetry based on chromosomal aberrations

This is a brief synopsis and UK HSA can provide fuller information, e.g. copies of publications if requested.

A small (5-10ml) sample of heparinised blood can be sent by post or courier to the laboratory and a minimum of three working days are needed after receipt of the specimen; two days for cell culturing and one day for microscopy. Metaphases from T-lymphocytes are prepared and analysed for chromosomal damage caused by radiation. The dicentric aberration is used to indicate exposure because: a) it is easily identified; b) it is practically unique to radiation, i.e. no confounding effect of mutagenic chemicals; c) it has a low background level (~1 in 1,000 cells); and d) it has a highly reproducible dose response relationship that, with a few exceptions, shows little difference between individuals. The level of effect is dependent on radiation type, i.e. x-rays; gamma-rays; neutrons and therefore a set of dose response curves, typical of the various radiations commonly encountered in accidents, has been prepared. With x- and gamma-rays the effect is also dependent on the time over which the dose is received and whether it is continuous or intermittent. For unbroken exposures lasting for more than 1 hour or interrupted exposures with gaps of 1 hour or longer some idea of the likely time course of the exposure is needed.

Because the particular sub-sets of T-cells examined have a fairly long lifespan (~3 yr half-life) it is possible to carry out the analysis at considerable times after the irradiation. A sampling delay of up to 1 year would not seriously prejudice the assay. The lower limit of dose detection by this method is about 100 mGy of x- or gamma-rays, although at this level there are considerable uncertainties based on sampling statistics. This is because only 500, or occasionally 1000 cells, are examined. The results of the test are given as the most likely estimate of averaged whole-body dose with 95% confidence limits. This means that the true dose falls within these limits with at least 95% certainty. The method gives an estimate of dose from penetrating radiation; therefore, it is not applicable to exposure from soft x-rays or surface contamination with α or β particles. Non-uniform or partial body irradiations may occur. Sometimes an allowance can be made for this by statistical methods, but the technique is not applicable to very localised exposures, e.g. dose just to a hand.

When advising an irradiated person, it is worth noting that the presence of aberrations in the blood lymphocytes is in itself of no health consequence. Therefore, the technique is a biological dose meter and not a risk meter. However, it can be inferred that chromosomal damage also would have been induced elsewhere in the body such as in important stem cells. To determine a risk of induced cancer from an accidental irradiation, one may take whatever dose information is available, including that from chromosomal aberrations and apply risk coefficients such as those recommended by the International Commission on Radiological Protection. Advice on such calculations can be obtained from the UK Health Security Agency Centre for Radiation, Chemical and Environmental Hazards.

UK HSA Chromosomal Dosimetry Service: https://www.ukhsa-protectionservices.org.uk/cds/