CALIBRATION CURVE RELATING RADIATION DOSE FOR MIXED GAMMA AND THERMAL NEUTRONS TO ABERRATION YIELDS IN CYTOGENETIC DOSIMETY USING PERIPHERICAL BLOOD LYMPHOCYTES

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INTRODUCTION

During the last two decades, dosimetry by means of chromosomic analysis has become a current technique in the assessment of doses in abnormal situations (1). This practice serves as a supplement to physical dosimetry in accidental radiological evaluations.

The dose estimations made have been consistent with both clinical and physical evaluations (2). This is the biological technique with the lowest detection level in accidental overexposures, approximately 0.1 Gy with a low LET. Although it does not have the capacity of estimating doses within the boundaries of occupational doses, due to the accumulation of chromosomic aberrations that occurs as time goes by, it may be a useful technique for the detection of overexposures that were not identified previously or as a supplement of those obtained by means of physical dosimetry.

The frequency of chromosomic aberrations induced in linphocytes of the peripherical blood depends on the dose and on the LET. When dealing with low LET radiations, it also depends on the dose rate.

The development of the nuclear industry has increased the number of problems connected with radiological protection. Considering that physical dosimetry applied to high LET radiations is a complex technique, the application of cytogenetic dosimetry may become an important contribution.

In order to estimate doses in criticality accidents, our laboratory performs dosimeter calibrations by means of chromosomic analysis for mixed gamma radiation fields and for thermal neutrons.

MATERIALS AND METHODS - CULTURAL CONDITIONS

The conditions under which the culture of peripherical blood lynphocytes is performed have already been widely described. The differences in the techniques applied by the various laboratories have been presented as one of the main reasons for the variations observed in the relation between the doses and the frequency of induced chromosomic aberrations.

For this purpose, our laboratory has adopted the recommendations introduced by a programme coordinated by the IAEA (3), whose synthesis indicates that:

1. each laboratory must always attach itself to a strict standard protocole;

2. only those cells within the first mitotic division must be marked;

3. the fastenings must be performed when the curve of the first mitosis reaches its peak;

4. a culture containing 5-bromodeoxiuridine must be processed along with the rest, in order to assess the frequency of cells in the first, second and other divisions, which are eventually used for marking, if necessary;

5. by applying the former criteria, each laboratory must perform its own calibration with blood samples obtained from at least three different donators.

Each point of the calibration curve is estimated as from the analysis of 500 metaphases. Both the fraction of dicentrics and the rings per cell are assessed for each dose.

IRRADIATION CONDITIONS

Irradiations were performed at different positions of the thermal column in a production and research reactor, at doses between 0 and 4 Gy.

The blood was exposed in 10 ml hermetic polyethilene tubes, with three pairs of thermoluminiscent dosimeters (TLD 600 and 700) attached to their external walls.

At the same time, a calibration curve was obtained with gamma radiations from a Co-60 source, by applying the same cultural technique.

RESULTS

It is assumed that the gamma and neutronic components of the mixed field produce additive effects (4).

Microscopical observation does not allow to see the chromosomic aberrations produced by either component.

In order to attain this goal, knowledge must be gained on the gamma/thermal neutrons ratio, so as to assess the separate contribution of each type of radiation in the fraction of chromosomic aberrations observed.

For each dose in the mixed field, the fractions of chromosomic aberration induced by cells must be assessed and the corresponding function is adjusted as per such fractions.

The ratio between the fraction of cell-induced chromosomic aberrations and the gamma dose is that used, as from a previous calibration, in the estimation of doses in accidental overexposures with low LET radiations. Finally, the ratio between the fraction of cell-induced chromosomic aberrations and the thermal neutron doses is assessed for each dose as from the difference between the calibration curves adjusted with mixed field and with gamma radiation.

The calibration curves obtained for each type of radiation are the following:

I. Gamma radiation

Dicentrics plus rings

$$Y = 0.001 + 6.5\ 10^{-6}\ \frac{\text{dicentrics + rings}}{\text{cell} \cdot \text{rad}^2}\ D^2$$

II. Thermal neutrons

Dicentrics plus rings

$$Y = 0.001 + 2.41\ 10^{-3}\ \frac{\text{dicentrics + rings}}{\text{cell} \cdot \text{rad}}\ D$$

CONCLUSIONS

Biological dosimetry performed by means of chromosomic analysis for mixed gamma radiation and thermal neutron fields is a supplementary technique in physical dosimetry. It is needed for estimating doses in criticality accidents.

The gamma/neutron ratio assessed by means of physical dosimetry is needed in every case for estimating the contribution of each component.

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