CHROMOSOME ABERRATION OF ACCIDENTALLY EXPOSED PERSONS IN FRANCE : REVIEW OF CASES 1992-95.

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INTRODUCTION

Since more than 20 years, biological expertise concerning dose estimation of suspected overexposure of personnel to ionising radiation has been undertaken by a small number of laboratories in each continent (1). Dose estimation by change of some biological parameters appears a useful compliment to clinical and physical dosimetries together with the knowledge of the health status of the potentially exposured people. It becomes particularly important when physical dosimetry is not present and clinical dosimetry is not consistent (2). Biological estimates of accident overexposure is usually obtained by the scoring of radio-induced unstable structural chromosome aberrations (dicentrics, centric rings and fragments) in peripheral blood lymphocytes (3). A correlation between the dicentrics yield and the physical dose can be obtained by reference with an *in vitro* dose-response relationship, which is related to radiation quality and dose rate (3, 4). Although some new biological indicators such as micronuclei or translocation yields may constitute interesting alternatives, dicentric scoring is considered as the most specific and sensitive biological dosimeter.

During the 1992 - 1995 years period, 33 persons were investigated by the Laboratory of Multiparametric Biological Dosimetry of the Institute of Protection and Nuclear Safety (I.P.S.N.) for a potentially overexposure accident. Although limited, this number of cases was considered large enough for a first statistical overview. This report summarises the related observations and conclusions.

METHODS USED

A blood sample is collected during medical examination of the patient by antecubital venepuncture in tubes containing lithium heparin as anticoagulant (Becton Dickinson).

After arrival in the laboratory, the lymphocytes are cultured using a protocol similar to that described in the IAEA technical report (4). Briefly, several replicates of each blood sample were added to a culture medium (Life Technologies) supplemented by phytohaemaglutinin (PHA, Life Technologies), a mitogenic factor of lymphocytes, heat-inactivated fetal calf serum and antibiotics. Bromodeoxyuridine (BrdU, Sigma), a thymidine analogue, is also included in the blood culture, in order to score unstable chromosome aberrations in the first metaphases.

After 46 hours of culture at 37 °C, a mitotic inhibitor (Demecolcine, Life Technologies) is added and culture delayed for 2 hours. Cells are harvested and metaphase spreads prepared according to standard techniques. The slides were stained with Fluorescence Plus Giemsa (FPG) so that cells in their first and second divisions can be distinguished.

Unstable chromosome aberrations (dicentrics, centric rings and fragments) are scored microscopically only in the first complete metaphases (with 46 centromeres). The estimation of potentially received dose is made by reference to dose response curve produced by exposing blood *in vitro* to ^{60}Co gamma rays at 0.5 $Gy.min^{-1}$:

$$Y = 0.042 \times D + 0.054 \times D^2$$

(Y = yield of dicentrics and D = dose in Gy)

RESULTS and DISCUSSION

Several reasons are behind an expertise of biological dosimetry by cytogenetics, in case of suspicion of exposure to ionizing radiation. The most common one is that potentially exposured people, professional or public, do not carry a physical dosimeter when an overexposure is suspected (24 out of 33 cases). Even when there is possibility of *a posteriori* dosimetric reconstruction, uncertainties linked to the former justifies the examination of a biological parameter linked to the subject himself. A second reason is that, although a physical dosimeter is

effectively carried in the frame of their professional activities, the registered dose was abnormally high or took into account only localised irradiation (9 out of 33 cases). Five cases have concerned people submitted to chronic or fractionated irradiations, so that the biological estimate appeared as a useful adjunct in the knowledge of the current status of the patient.

Suspicion of overexposure can be divided in two major categories (Table 1): people whose professional occupation consists of working with radio-activity, radio-active sources or close to them (so called « professional » in table 1), and persons whose activities (professional or private) do not usually include usage of ionizing radiation. These former ones are called in this report with the general term « public ». It can therefore be surprisingly observed in the period 1992-95 a global imbalance between these two categories, an imbalance that however is not found for all years. In addition, whatever the category of persons is, the suspicion of irradiation always concerns the external exposition, never the internal contamination.

Table 1. Distribution of the number of personnel suspected of overexposure during the period 1992-95, according to the « professional » or « public » status of exposured persons.

	Number of cases		
Years	« professional »	« public »	Total
1992	5	10	15
1993	3	2	5
1994	2	1	3
1995	7	3	10
Total	17	16	33

According to their main professional activities, three classes of workers can be distinguished under the vocable « professional » (table 2). The distribution of suspected overexposure accidents shows a relative homogeneity of the accidental origin for these three classes : gammagraphy sources for testing purposes that constitutes the majority of typical industrial irradiations generally involves problems linked to dysfunction of the devices. In the health institutions, whether for radiographic use or patient treatment, it most often concerns the inattention of operators to protection and safety details. The greatest variability of the origin of accidents is linked to nuclear industry. This was probably due to the introduction in this category of three foreign persons who came to France for medical examination. On the one hand, it concerns a maintenance worker of the Chernobyl nuclear power plant during several years following the fallout and a physicist having periodically studied the reactor core inside the sarcophagus for 4 years. On the other hand, it includes a foreign physicist with badly irradiated hands by an accelerator of electrons. No dicentrics were scored in the first case what was coherent with clinical status of the patient. In the second case however, the biological dose (0.42 Gy) was clearly under-estimated in contrast with the diagnosis of total sterility. For the last one, the physical dosimetry reconstruction has suggested a dose within the range 10-40 Gy to both hands. This is quite different from 6 dicentrics scored in 500 lymphocyte metaphases which gives an integrated dose of 0.3 Gy. This example underlines well the limitations of cytogenetic dosimetry in case of very localized irradiation.

Table 2. Distribution of professional workers in three categories, and presence or absence of physical dosimeter (generally chest dosimeter) during the suspected overexposure accidents.

Physical dosimeter	with	without	Total
industrial radiography	4	2	6
health institutions	1	4	5
nuclear organisations	4	1	5
Total	9	7	16

The Table 2 also shows the proportion of potentially classified workers who carried a physical dosimeter (finger, chest) during their professional activities and/or their overexposure period. As far as the limited number of

overexposed cases observed allows, it can be stressed, therefore, a radioprotection problem, especially for the health workers category.

Within the « public » category, many overexposure suspects imply persons who was working beside a source of ionizing radiation and who believed have been exposed accidentally; for example, unknowingly entering in the irradiation room when the source is functional. The result of all this is generally short, acute exposure. However, a case of particularly important chronic irradiation concerns a family (the father and two children) having recovered and stored a small source of 4 Ci (148 GBq) of ^{137}Cs. The father who recovered the source, has kept it only for a short time in his office before giving it to his son. The son has kept it for sixteen months in his bedroom, which was beside his sister's room. The doses estimated by biological dosimetry correctly reflected the duration of the exposition as well as the personal dose distribution (in equivalent whole body, 0.5, 0.9 and 0.64 Gy respectively). In contrast, it does not allow to reconstitute correctly the dose absorbed by the son notably because a strong lymphopenia.

More generally, the estimated dose has been « zero dose » or doses below 0.5Gy in the great majority of cases of these three years as summarised in Table 3. A « zero dose » means that no dicentrics have been found in the observed metaphases, often 500. However, there exists a possible minimum number of dicentrics to be observed in normal individuals, which is approximately 1 for 2000 metaphases. This suggests that the estimated dose is in fact included in the background considering that the accuracy of the method is proportional to the number of metaphases observed. On the curve of reference of the laboratory (^{60}Co, 0.5 $Gy.min^{-1}$), this corresponds to a 95% confidence interval of 0.2 Gy.

Table 3. The dose ranges estimated by biological dosimetry related to the repartition of the overexposured cases according to the different categories of implied people.

Dose range (Gy)	« zero dose »	0 - 0.19	0.2 - 0.49	0.5 - 0.9	Total Number
industrial radiography	2	1	3	0	6
health institutions	5	0	0	0	5
nuclear organisations	3	0	2	0	5
public	8	0	3	5	17
Total	18	1	8	5	33

It is necessary to note that the main limitation of the biological dosimetry is to give a dose integrated to the body, which poses problems in case of localized irradiations. It is indisputable that the majority of overexposures to ionizing radiations concern localized irradiations. In the three cases where hands have been mainly exposed to doses above 10 Gy, the dose given by dicentric scoring did not exceed 0.3 Gy. Furthermore, the selection of the reference curve has incontestably an importance on the estimation of the dose, independently of the presence or not of dicentrics, since it would have to take into account the quality of the radiation and the dose rate when they are known. In our experience for the years 1992-95, it appears that implied radiation sources are essentially from ^{192}Ir,^{60}Co, X -rays with a low dose rate. This justifies therefore the use of a reference curve established from gamma radiation of ^{60}Co with 0.5 $Gy.min^{-1}$. The comparison with the physical dosimetry in the cases where the former is known with a good accuracy shows elsewhere a good agreement with the cytogenetic estimate. Nevertheless, other reference curves for other qualities of radiation and dose rate are prerequisite.

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