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Full Length Research Paper

The epidemiological investigation of human chromosome aberrations in the different occupational situations in Vietnam

Hai T. D.[1], Duy P. N.[2], Luyen B. T. K.[2] and Que T.[2]*

[1]The Lamdong Technical & Economic Institute, Dalat, Vietnam.
[2]Biodosimetry Section, Nuclear Research Institute (NRI), Vietnam Atomic Energy Institute (VINATOM), Dalat, Vietnam.

*Corresponding author. E-mail: bionri@hcm.vnn.vn, tranquenri@gmail.com

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Along with the calibration of dose-effect such as the calibration dataset, the background dataset were tools of biodosimetry assessment. The data of personal management on status of chromosome aberrations yearly in the radiation workers will (not only) provide a personally spontaneous data for biodosimetry, but also make databases for warning and controlling the risks at radiation works. The objectives were 83 facility workers (group 1), 136 nuclear scientists and workers (group 2) and 37 imaging diagnosticians (groups 3 and 4). The normal evidence of chromosome aberrations were showed in the group 1, dicentric was detected in only a donor with frequency 1/1064 metaphases (0.094%). Dicentric, fragment and chromatid break were detected in group 2 with frequencies 0.01 ± 0.08, 0.26 ± 0.40 and 0.24 ± 0.24 respectively. In the group 3 and 4, the personal frequencies in percent of dicentric, fragment and chromatid break were respectively in range 0.03 to 0.06%, 0.12 to 0.25% and 0.12 to 0.28%, but there were abnormal on detecting dicentric frequency (3 dicentrics in a metaphase). In a CT scan, technician and appearance of radical chromosome aberration type increased from year to year.

Key words: Chromosome aberration (CA), imaging diagnostician, Ir192 radiation source, radiation worker, y_{di}: dicentric %, y_{frag}: fragment %, y_{chb}: chromatid break %, y_{rad}: radical %.

INTRODUCTION

The preparedness of the background and caliration dose-efect datasets was necessary for conducting of biodosimetry in any biodosimetry laboratory. The background dataset of chromosome aberration in peripheral blood lymphocyte of the donors who worked in the different situations was the main objective of this investigation. Epidemiological investigation of human chromosome aberrations in different groups has a mission to prepare background dataset on chromosome aberration for biodosimetry in Vietnam. The epidemiological investigation of Que et al. (2000, 2004, 2009, 2010, 2014) showed the status on type and frequency of chromosome aberration in the groups: workers, farmers and victims of orange chemical toxins. Abnormal evidence on types and frequencies of chromosome aberrations in the donors who were using phosphorus pesticides for planting was published (Que et al., 2000, 2004). The strong development of the radioactive sources in medicine, industry along with the problems of toxic residues in agriculture are the factors causing instability in health status, and interfering in biodose assessment needs to be investigated.

Chromosome aberration is formed from the DNA damage; it means that chromosome aberration is an indicator of mutagenic impact. Therefore, chromosome aberration has interfered by the environmental contamination toxins (Evans, 1976; Leonard, 1993, 1988; Leonard and Bernard, 1993; Natarajan, 1984; Que et al., 2000, 2004). One of the important characteristic of the chromosome aberration was to distinguish the effects of radiation from the effects of chemicals (IAEA, 1986; Savage, 2004, 1976). Radiation creates the blunt ends of

double strand break (DSB), single strand break (SSB) while directly chemical deletions are not strand breaks. The second chemical deletions are normally unblunt end of DSB and SSB (Bender et al., 1988; Savage, 1976). The types of chromosome aberrations are indicators to warn the potential risk of environmental contaminated agents; these play an important role in monitoring the evolution of the status of radiation safety for radiation workers. Medical management of chromosome aberration is not only a task of epidemiological surveys but also a responsibility for monitoring and controlling changes in health and safety.

The epidemiological data was of interest very early. It almost investigated with number donors exceeding 10 that Lloyd summarized were not exceeding 0.10% dicentric, 1.5% fragments (Awa, 1983; Awa et al., 1992). Report of O'Riodan, 1978 presented that frequency of chromatid breaks was about 0.10%. Research results from Awa (1983, 1992), Bender (1988), Leonard (1988), Lloyd et al. (1980) and Tonomura et al. (1983) showed that dicentric frequency in natural communities was not exceeding 0.28%, fragment ~1.05% and chromatid break ~2.0%.

For the radiation workers, increasing dicentric 2 folds in group of plutonium job (di. 0.5% compared with 0.25% in controls) and 5 folds in group of workers of nuclear equipment center Elbmarsch (di. 0.18% compared with 0.046% in control) were showed by Dolphin in 1973. Survey results of Pohl and (1983), Ruling, Scheminzky (Austria, 1977), Franca (Brasill) and Brandom also showed that there were difference on CA frequencies between regions with different radioactivity (Brandom and Bloom-Arthur, 1983). Analysis of Stephan and Oestreicher (1993) in the group infected with the fallout from the Chernobyl accident observed dicentric with frequencies in valid of 0.24 - 0.16%, fragments in valid of 0.82%.

Tonomura et al. (1983) found the relationship between dicentric frequency (y) and age (X, X = 10 years) according to the formula $y = 2.18.10^{-4} + 1.7.10^{-4}$. X (X – time for 10 year old), which means that under 40 years old has dicentric frequency ≤ 1/1000 (0.01 %) and from 40 to 90 years old has dicentric frequency from 1/1000 to 2/1000 (0.01% - 0.02%).

International Conference on the use of biological effects in the genetic evaluation of toxic chemicals in Luxembourg in July 1987 recommended using CA such as an early indicator for detecting aspect of environmental contamination by chemicals. Beek, Carrano, Evans, More, Obe, Natarajan et al. (1982) said that CA of peripheral blood lymphocyte was a principle indicator for detecting mutations deriving from chemical contaminants in the environment (Evans, 1976; Leonard, 1993, 1988; Leonard and Bernard, 1993). The high frequencies of CA were reported by Peter and Neurath(1972), Schmid-Ullrich, Sigel, Wolf, Deknudt and Leonard. These results related to the residents who usually used pesticides or occupied in the contamination area of arsenic, cadmium or mercury.

The epidemiological studies of Que et al from 1990 to 2012 showed the status on type and frequency of CA between the groups: workers, farmers and victims of orange chemical toxins. The dicentric frequency in the worker group was invalid ≥ 0.1%, fragment ≥ 0.20%, the chromatid break ≥ 0.20%; unusual status of types and frequencies of CA were detected in the farmers who used pesticides made from dimethoat (1998 - 2000). Abnormal evidence on types and frequencies of chromosome aberrations in the donors who were using phosphorus pesticides for planting was published by Tran Que et al. in 1998. In this paper, Tran Que reported that $Y_{di} = 0.05 \pm 0.17$; $y_{fra} = 1.31 \pm 0.98$; $y_{chb} = 1.59 \pm 1.07$; $y_{rad} = 0.09 \pm 0.24$ (Que et al., 2004, 2009).

An abnormal evidence of on type and frequencies of chromosome aberration in the groups of doctors and technicials of hospital were showed by Vilena et al. (2008).

The strong development of the radioactive sources in medicine industry along with the problems of toxic residues from the war and uncontrolled use of agricultural chemicals are the factors causing instability in health status and interfering in biodose assessment. Those influences should be monitored and controlled by medical management.

Along with the calibration of dose-effect such as the calibration dataset, the background dataset were tools of biodosimetry assessment. These studies have been prepared for medical emergency to deal with radiation and environmental risks in populations.

MATERIALS AND METHODS

Materials used

Group 1 includes 83 donors who were workers of the facility installed company, who did not regularly use the Ir192 source to inspect weld of facility. Group 2 includes 136 donors who were scientists and workers of 6 sections: Nuclear Analysis (NA), Nuclear Physic and Radiation Protection (PP), Isotope Produce (IP), Reactor (R), Radiation chemical (RC) and other (O). Group includes 7 donors who were imaging diagnosticians from hospital of province 1. Lastly, Group 4 includes 30 donors who were imaging diagnosticians from hospitals of province 2.

Methods

10 ml whole blood of each donor was taken and stored in Na-heparin. Next was the cell culture in which the whole blood culture was in medium RPMI 1640 (sigma) with 15% FCS, PHA 10 µg/ml and it was later put in incubator

Table 1. Status of chromosome aberrations related to working groups, working years and year old of the donors.

Parameters	subsections		Working years			Year old		
	A	B	≤ 4	5-12	13-16	25-40	41-50	>50
No. of donors	88	45	10	10	115	42	76	17
y_{di}	0.01±0.08	0	0	0	0.02±0.08	0.01±0.08	0.01±0.06	0
y_{frag}	0.26±0.40	0.17±0.29	0.21±0.22	0.26±0.39	0.26±0.32	0.19±0.36	0.28±0.38	0.11±0.22
y_{chb}	0.24±0.24	0.12±0.30	0.15±0.33	0.20±0.32	0.15±0.36	0.22±0.36	0.26±0.55	0.05±0.13
y_{rad}	0.01±0.07	0	0	0.01±0.05	0.01±0.07	0.01±0.04	0.01±0.07	0

37°C/48 h. Colchicine was added at 46 h of cultured time. The slides with conventional dye were used to analyse chromosome aberration. Next was the chromosome aberration analysis whch includes counting dicentric, ring, fragment, chromatid break and radical. The theory of classification of savage was used for correcting types of chromosome aberration. Frequencies of chromosome aberration types were counted from 1000 metaphases (minimum number of metaphases for 1 dicentric follow Tonomura $y = 2.18.10^{-4}+1.7.10^{-4}.X$); using value % for frequency of chromosome aberration. Statistical methods were used to check data. In addition, age and working environment of the donors were auxiliary parameters for discussion of analysis results.

RESULTS AND DISCUSSION

The evidence of chromosome aberrations in the group 1

Group 1 includes the donors who were workers of the facility installed company, who did not regularly use Ir192 resource to inspect weld of facility. Eighty three donors had to examine chromosome aberration. Fragments were detected in 28 with very low frequency, only one donor got frequency over 4/1064 metaphases (0.37%). In addition, chromatid breaks were detected in 35 donors, only two donors got 3 fragments in ~1000 metaphases. Furthermore, dicentric was detected in only a donor with frequency 1/1064 metaphases (0.094%).

The evidence of chromosome aberrations in the group 2

Group 2 includes the donors who were the scientists and workers of Nuclear Research Institute. All the samples of 136 donors were analyzed, 47% of population was found with chromosome aberrations. The ratio of donors that got dicentric, fragment and chromatid break were respectively 2, 26 and 29%. Chromosome aberration frequencies in the donors of NA, PP, IP and R sections (A subsection) were higher than that in the remaining sections (B subsection) of the investigated population. The analysis data in 4 sections were $y_{di} = 0.014 \pm 0.080$, $y_{fra} = 0.260 \pm 0.040$ and $y_{chb} = 0.240 \pm 0.040$. Dicentric was not detected in the remaining groups, frequencies of fragment and chromatid break were respectively 0.170 ± 0.090% and 0.124 ± 0.030%. This result presented that the status of chromosome aberration were fixed in the low average group. Status of chromosome aberrations related to working groups, working years and ages of the donors is shown in Table 1.

Frequencies of dicentric, fragment and chromatid break detected in subgroup A were higher than these in subgroup B, in working years 13-16 higher than these in working years 5-12 and in year old 41-50 higher than these in year old 25-40 and >50. Using t-test to estimate distribution of chromosome aberration frequencies showed that these results were not different with them in normal population (group 1).

The evidence of chromosome aberrations in the group 3

Group 3 includes the donors who were imaging diagnosticians from hospital 1. Seven imaging diagnosticians from hospital, some of them were detected an abnormal on physical doses but not over than 10 mGy. An abnormal in types and frequencies of chromosome aberrations are shown in Figure 1 and Table 2. Three donors had y_{di} ~ 0.01; 2 donors had y_{di} ~ 0.02. Average frequencies in percent of dicentric, fragment and chromatid break were respectively 0.098% ± 0.082, 0.73% ± 0.27 and 0.75% ± 0.39.

The evidence of chromosome aberrations showed an abnormality on frequencies of irradiated chromosome aberration types, such as dicentric and fragments. The appearance of radical and extra chromosome was also found in this group. In addition, the frequency of chromatid breaks was high.

The evidence of chromosome aberrations in the group 4

Group 4 includes the donors who were imaging diagnosticians from the hospitals in the province 2. Thirty

Figure 1. Abnormal in types of chromosome aberrations.

Table 2. The evidence of chromosome aberrations detected from the donors of hospital in the province 1.

Donors	Cells analysed	y_{di}	y_{frag}	y_{chb}	y_{ra}
1	1086	2 (0.18)	12 (1.10)	6 (0.55)	1 (0.09)
2	932	-	4 (0.43)	13 (1.39)	1 (0.11)
3	961	1 (0.10)	6 (0.62)	8 (0.83)	-
4	915	2 (0.22)	7 (0.76)	10 (1.09)	-
5	991	1(0.10)	10(1.01)	7 (0.71)	-
6	1068	1(0.09)	9 (0.84)	4 (0.37)	-
7	1057	-	4 (0.38)	3 (0.28)	-
Average		0.098 ± 0.082	0.734 ± 0.275	0.746 ± 0.395	

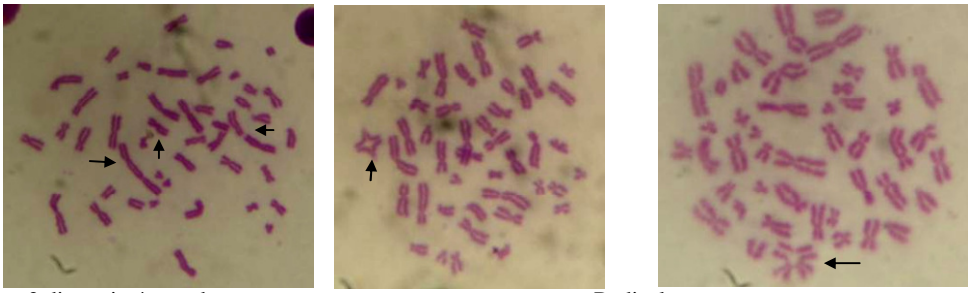

Figure 2. Detection of dicentric, fragment, chromatid break and the abnormal of radical.

donors who were imaging diagnosticians from 6 hospitals were tested yearly for chromosome aberrations from 2009 to 2012. These annual data are shown in Figure 2 and Table 3. Dicentric, fragment, chromatid break and the abnormal of radical were detected from the donors of this group, the evidence is shown in Figure 2 and Table 3.

In the population level, the frequencies of dicentric, fragment and chromatid break were respectively in range 0.03 to 0.06%, 0.12 to 0.25% and 0.12 to 0.28% were in the range of spontaneous, but there were the abnormal: detecting dicentric frequency (3 dicentrics in a mataphase) in a CT scan technician donor and appearance of radical type. The evidence of radical type was abnormal in the donors of group 3 and 4 and seemed to be increasing from year to year.

In the personal level, the abnormalities on frequencies showed difference among donors who had different relative degree to radiation source, but not depending on age. The higher frequencies of chromosome aberration

Table 3. The annual data of chromosome aberration analysed from the hospitals of province 2.

year	Number of donors	Metaphases per donor	Y_{di}	Y_{frag}	Y_{chb}	Y_{rad}
2009	12	1002	0.03 ± 0.06	0.25 ± 0.10	0.13 ± 0.13	-
2010	13	997	0.05 ± 0.05	0.18 ± 0.14	0.28 ± 0.17	0.02 ± 0.04
2011	13	1017	0.06 ± 0.06	0.19 ± 0.10	0.12 ± 0.11	0.03 ± 0.05
2012	11	1008	0.04 ± 0.09	0.12 ± 0.11	0.13 ± 0.11	0.06 ± 0.07

were detected in donors 1, 2, 8 and 9 who were X rays, CT technicians.

Radical aberration is a chromatid aberration that is related to relink 2 blunt ends of SSB in the cases of not being repaired. There was an abnormality in the ratio of the donors who had radical aberration in the group; radical aberration was detected in 6 donors of group including 11 donors in 2012, this phenomenon had never been seen before.

Type of chromosome aberration induced in first metaphase is shown to know the types of DNA damages in G_1; it means type of chromosome aberration in the first metaphase as a result of DNA damaged type due to ionizing radiation or chemicals. One of the important characteristic of the chromosome aberration was to distinguish the effects of radiation to the effects of chemicals. Double-stranded lesions beginning with the characteristics of radiation effects, relinking the adhesives of fragments that caused by double strand break (DSB) will form the unstable aberrations such as dicentric, fragment, ring. The damages due to the impact of the chemical mutagens often result from unrepair or misrepair of DNA base damages; this fact leads to secondary deletions as DSB unblund ends or SSB. Relinking two DSB unblund ends will be completed only with 2 adhesive ends that have supplemented mononucleotids; it means that relinking of two DSB unblunt ends was rare event. In this case, almost DSB in G1 phase will create fragments and frequency of dicentric will be normal.

In the case of chromatid aberration, chromatid aberrations including radicals were created by relinking of SSB from G_1 phase or DSB after S phase. Chromatid breaks have a low frequency in the exposed samples because almost SSB were repaired quickly, but SSB due to radiation will be stored if repair enzymes are inactive. The status of high radical frequencies analyzed in the imaging diagnosticians can be understood as explained above.

Conclusions

The study concludes as follows:

(1) The normal frequencies of chromosome aberration were shown in the result for the donors who were the facility installed workers, who did not regularly use the Ir192 resources to inspect weld of facility. Frequencies in percent of dicentric, fragment and chromatid break were respectively under 1/1000, under 4/1000.

(2) The frequencies of chromosome aberration were in the range of spontaneous for the donors who were scientists and workers of Nuclear Research Institute. The frequencies of chromosome aberrations were $y_{di} = 0.01 \pm 0.08$; $y_{fra} = 0.26 \pm 0.04$; $y_{chb} = 0.24 \pm 0.04$. The status of chromosome aberration did not depend on working years of the donors.

(3) The abnormalities of chromosome aberrations were detected in the donors who were the imaging diagnosticians in the hospitals. The high frequencies of fragment and chromatid break were detected in the donors in the hospital of province 1. For the hospitals in province 2, in the population level, the frequencies of dicentric, fragment and chromatid break were respectively in range 0.03 to 0.06%, 0.12 to 0.25% and 0.12 to 0.28% were in the range of spontaneous, but there were the abnormal: detecting dicentric frequency (3 dicentrics in a mataphase) in a CT scan technician donor and appearance of radical type. The evidence of radical type and increasing from year to year were abnormal for the donors who were imaging diagnosticians.

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