Biological Dosimetry - Cytogenetics Findings At Persons Occupationally Exposed To Ionizing Radiation

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Abstract

A large number of physical and chemical agents are capable to course chromosomal aberrations. Ionizing radiation is frequent and well known course of chromosomal aberrations. If deoxyribonucleic acid (DNA) is irradiated before synthesis chromosomal – type aberrations are caused. Chromatid – type aberrations are results of DNA damages occurred during or after synthesis. Some of these changes could exist at patients several years after exposition. Biological dosymetry – cytogenetics analysis of persons occupational exposed to ionizing radiation in Federation of Bosnia and Herzegovina have been carried out in "Center for Human Genetics" of Medical Faculty in Sarajevo. In this study we have evaluated cytogenetics findings of persons employed in a zone of radiation. Cytogenetics findings have been demonstrated in allowed limit in 154 (81,1%) examinees, and cytogenetics findings were out of normal values in 36 (18,9%) examinees. The majorities who have been employed in a zone of ionizing radiation were in age group 40-44 (25,3%) and age group 45-49 (24,7%). Radiological technicians (35,7%) were exposed the most to ionizing radiation, than clinical nurse specialists (14,7%), radiologists (11,1), physicians (7,4%) machines technicians (6,3%), pneumologist (4,7%), orthopedists (4,2%) and scrub nurses (4,2%). Biological dosimetry – cytogenetics analysis have been carried out at 108 (56,8%) male and 82 (43,2%) female examinees. The most frequent aberration have been presented with 26,8% in the form of acentric fragments, than chromatid fragments with 21,2%, dicentric chromosomes with 19,5%, gaps with 18,7%, minutes with 12,2% and interarm interchanges with 1,6%.

KEY WORDS: findings of biological dosimetry, exposition to ionizing radiation

Introduction

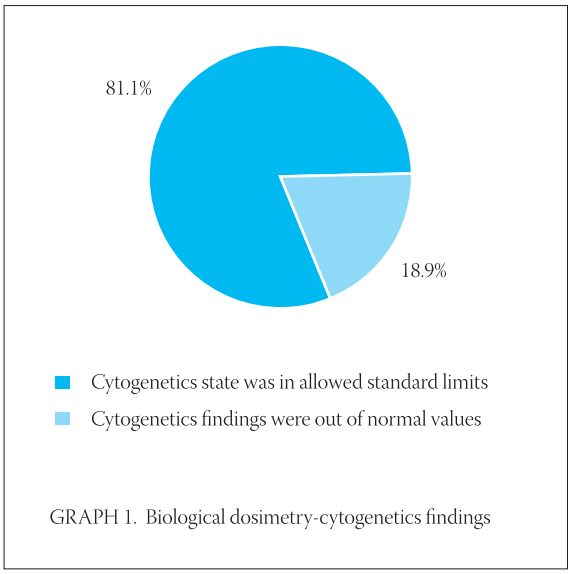
The chromosomal damages, chromosomal aberrations can be detected by cytogenetics analysis. Chromosomal aberrations are mutations on chromosomal level that course irregularities in the number or structure of chromosome of one species. Numerical irregularities with changed number of chromosomes in cell are coursed by disturbance in separation and moving of chromosomes or chromatids during cell division. Structural irregularities are coursed by breakages (transversal breakages of chromatids or chromosomes with reunion of segments or without reunion); the results can be balance or unbalance chromosomal rearrangements. These irregularities can occur during meiosis (reductional or gametic cell division) and mitosis (equal or somatic division). Irregularities happened during mitosis are connected with aging process and cell cancer transformation, and irregularities happened during meiosis are responsible for changed genetics materials of offspring (1). A large number of chemical and physical agents could induce mutation of genetics material. Ionizing radiations is major mutagen agent. Hermann Joseph Muller, the father of radiation genetics, studded mutations in fruit flies *Drosophila melanogaster*) and artificially increased the mutation rate by means of X ray (2). For this discovery he was awarded the 1946 Nobel Prize in Physiology and Medicine. Radiation is frequent and good known course of chromosomal aberrations in the peripheral lymphocytes and myeloid cells of bone marrow. If deoxyribonucleic acid (DNA) is irradiated before synthesis chromosomal – type aberrations are caused. Chromatid – type aberrations are results of DNA damages occurred after synthesis. Some of these changes could exist at patients several years after exposition. The relationship between these changes and possible biological effects is not well known. Irregularities in the number or structure of chromosome can be detected by means of the microscope analysis. Bender and Gooch were first who suggested analysis of chromosomal aberrations in human lymphocytes to detect and quantify radiation exposures (3). In its conventional form, chromosome analysis is largely based on the scoring of uniformly stained dicentrics in metaphase preparations of peripheral lymphocytes (4). Dicentric chromosomes as a consequence of irradiation can be found in the organism up to 3 years after time of irradiation, which is actually the life span of lymphocytes (5). The basic goal of this study is to evaluate biological dosimetry – cytogenetics findings in persons employed in a zone of ionizing radiation and establish frequency of chromosomal aberrations.

Subjects and Methods

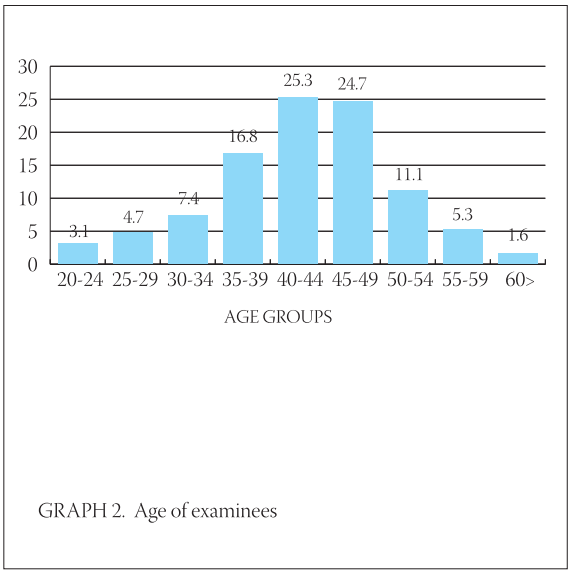
Cytogenetics studies are carried out in medical surveillance of persons employed in a zone of ionizing radiation. Chromosomal aberrations of peripheral lymphocytes are analyzed. The peripheral lymphocyte population, which is normally non-cycling, is precious, chip and simple source of chromosomal preparation because of short time taken in setting up a culture and sample is obtained easily. The culturing method is based on mitogenically stimulation of phytohaemagglutinin (PHA), so called mitotic vitamin. Under the influence of PHA the lymphocytes are transformed into blastoid cells after 48 hours. The procedure is to add 0,3 ml of whole blood and 0,1 ml of PHA to a vessel containing 4ml of medium and 1ml of serum and than incubate. Colcemid is used three hours before harvesting. After hypotonic treatment with KCl (0,075 M) for 20 minutes the lymphocytes are fixed in a mixture of methanol and icy acetic acid in ratio 3:1 and than material is dropped onto glass slides. Only clearly well spread complete metaphases are analyzed (6). In our study we have evaluated cytogenetics findings of 190 examinees employed in a zone of ionizing radiation during 2004.

Results

By means of biological dosimetry it was determined that cytogenetics state was in standard allowed limits in 154 (81,1%) examinees, and cytogenetics findings were out of normal values in 36 (18,9%) examinees (Graph 1). The majority who have been employed in a zone of ionizing radiation were in age group 40-44 (25,3%), then age group 45-49 (24,7%), age group 35-39 (16,8%), age group 50-54 (11,1%), and further as showed by Graph 2. Analyses of examinees by occupation pointed that radiological technicians (35,7%) were exposed the most to ionizing radiation, than clinical nurse specialists (14,7%), radiologists (11,1), physicians (7,4%) machines technicians (6,3%), pneumologist (4,7%), orthopedists (4,2%), scrub nurses (4,2%) and further as shown by Table 1. Structure of examinees (persons who employed in a zone of ionizing radiation) by sex is showed in Table 2. Biological dosimetry – cytogenetics analysis have been carried out at 108 (56,8%) male and 82 (43,2%) female examinees (persons who employed in a zone of ionizing radiation in 2004). Multiple chromosomal aberrations have been detected at 36 (18,9%) examinees – persons, who employed in a zone of ionizing radiation in 2004 in Faderation of Bosnia and Herzegovina (Graph 3). At 36 (18,9%) examinees – persons who employed in a



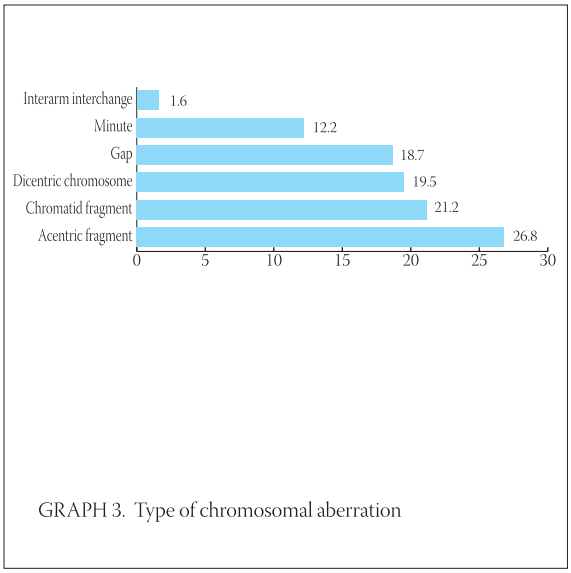
GRAPH 1. Biological dosimetry-cytogenetics findings



GRAPH 2. Age of examinees

OCCUPATION	STRUCTURE OF EXAMINEES	
	N⁰	%
Radiological technicians	68	35,7
Clinical nurse specialists	28	14,7
Radiologists	21	11,1
Physicians	14	7,4
Machines technicians	12	6,3
Pneumologist	9	4,7
Scrub nurses	8	4,2
Electricians and professional drivers	8	4,2
Orthopedists	8	4,2
Oncologists	3	1,6
Airport controllers	3	1,6
Internists	2	1,1
Photolaboratorians	2	1,1
Sanitarians	2	1,1
Chemists	1	0,5
Anesthetists	1	0,5
Total	190	100

TABLE 1. Occupation of examinees



GRAPH 3. Type of chromosomal aberration

STRUCTURE OF EXAMINEES					
Male		Female		Total	
N⁰	%	N⁰	%	N⁰	%
108	56,8	82	43,2	190	100

TABLE 2. Structure of examinees by sex

zone of ionizing radiation acentric fragments have been presented with 26,8%, chromatid fragments with 21,2%, dicentric chromosome with 19,5%, gaps with 18,7%, minutes with 12,2% and interarm interchanges with 1,6%.

Discussion

Workers in the nuclear industry and those who work with medical X-rays may be designated as "classified workers" and have their occupational radiation exposure monitored and recorded. The best method for biomonitoring is chromosomal aberration assay. The increased frequencies of chromosomal aberrations in radiation workers indicate the cumulative effect of low-level chronic exposure to ionizing radiation (7). Analysis of chromosomes aberration ought to be done:

1) in medical surveillance before starting with job in a zone in ionizing radiation,
2) every three years after previous medical surveillance,
3) if employer has been radiated with single dose higher than 50 mSv,
4) if employers are exposed to doze radiation higher than 5 mSv during work in a zone of ionizing radiation.

Frequency and type of chromosomal aberrations are out of control values for general population if there have been found in 200 analyzed metaphases:

- five or more acentric fragments,
- total number of acentric fragments and dicentric chromosomes is equal to five or higher,

- one or more dicentric chromosomes,
- one ring chromosome.

Frequency and type of chromosomal aberrations are on the top of control values for general population if there have been found in 200 analyzed metaphases:

- total number of acentric fragments is equal to four.

The finding is out of standard allowed values if there have been found more than three binuclear lymphocytes on 10.000 lymphocytes. The finding is out of standard allowed limit if there have been found marker chromosome occurred by reciprocal translocation or pericentrical inversion. If frequency and type of chromosomal aberrations are out of control values for general population examinee is not capable for work in a zone of ionizing radiation and control analysis should be done in 180 days. If frequency and type of chromosomal aberrations are on the top of limit of control values for general population examinee is capable for work in a zone of ionizing radiation but control analysis should be done in 180 days. Very high levels of ionizing radiation, such as that from a nuclear explosion, will course severe cell damage or cell death. This may lead to immediate death of individual as a result of acute exposure, or to longer-term consequences as a result of damage to the reproductive cells. It is more difficult to predict the effects of low-level doses of ionizing radiation such as cosmic radiation or medical X-rays because of individual variability in the body's self-repair process (8). The comparison of dosimetric date obtained by film-badge measurements and the frequency of dicentric chromosomes in some study revealed no correlation between the two observed parameters (9,10).

Conclusion

It was determined that cytogenetics state was in standard allowed limits in 154 (81,1%) examinees, and cytogenetics findings were out of normal values in 36 (18,9%) examinees using the method of biological dosimetry. The majorities who have been employed in a zone of ionizing radiation were in age group 40-44 (25,3%) and age group 45-49 (24,7%). Radiological technicians (35,7%) were exposed the most to ionizing radiation, than clinical nurse specialists (14,7%), radiologists (11,1), physicians (7,4%) machines technicians (6,3%), pneumologist (4,7%), orthopedists (4,2%) and scrub nurses (4,2%). Biological dosimetries, in its conventional form of cytogenetics analysis, have been carried out at 108 (56,8%) male and 82 (43,2%) female examinees. Multiple chromosomal aberrations have been detected at 36 (18,9%) examinees – persons who employed in a zone of ionizing radiation in 2004 in Federation of Bosnia and Herzegovina. The most frequent aberration have been presented with 26,8% in the form of acentric fragments, than chromatid fragments with 21,2%, dicentric chromosomes with 19,5%, gaps with 18,7%, minutes with 12,2% and interarm interchanges with 1,6%.

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