Developing Biological Dosimetry Laboratory for the Assessment of Radiation Overexposure in Saudi Arabia

Al- Zahrany, Awad[1,] *; Al-Hadyan, Khaled [2]; Ahmad Nobah[2], Saad Aldelaijan[3],Venturina, L. Aubrey [2]; Shoukri, Mohamed [2]; Moftah, Belal [2]; Alsbeih, Ghazi [2]

[1]Atomic Energy Research Institute, King Abdulaziz City for Science and Technology (KACST); Riyadh, Saudi Arabia
[3]Biostatistics Epidemiology and Scientific Computing, King Faisal Specialist Hospital and Research Centre (KFSHRC); [3]Executive Administration for Radiation Protection and Safety, Medical Devices Sector, Saudi Food and Drug Authority (SFDA); Riyadh, KSA

**Presenting author: Tel.: 00966-14813613; fax: 00966-14813646.E-mail address: azahrany@kacst.edu.sa*

Introduction

In cases of individual radiation overexposure or radiological accidents, it is important to provide suitable dose assessment, medical triage, diagnoses and treatment to victims. Cytogenetic abnormalities are one of the most striking and consistent effect of ionizing radiation on living organisms. When the energy associated with ionizing radiation is transferred to molecules in cells, the DNA that embeds the genetic materials is damaged in proportion to the type and amount of energy that is absorbed. In human lymphocytes, this leads to the appearance of structurally abnormal chromosomes when cells attempt to divide following radiation exposure. Between the different types of chromosomal aberrations induced, dicentric chromosomes appear to be more specific to radiation exposure with a background level practically equal to zero. Hence, the number of dicentrics is quantified and compared to a calibration dose-response curve, established *in vitro*, in order to derive an estimate of possible dose received. This strategy is valid because lymphocytes express the damage regardless of whether they are irradiated *in vivo* or *in vitro*. Therefore, the cytogenetic dicentric assay became the internationally recommended method for biological dosimetry by ISO (International Organization for Standardization, ISO 19238, 2004) and International Atomic Energy Agency (IAEA Technical Report Series No. 405, 2001). It uses the genetic effect of ionizing radiation on human body and relies on the frequency of dicentric chromosomal aberrations found in metaphases from cultured human peripheral blood lymphocyte.

The Main Objectives

1. Establish Biological Dosimetry capability, based on Dicentric Chromosomes Assay (DCA) biotechnology, in Saudi Arabia.
2. Determine the dose-response calibration curve in our population, pre-required to estimate accidental dose received.
3. Contribute to the preparedness plan of the "National Radiation Protection Program" by providing medical diagnostic test in case of nuclear or radiological accidents, as part of the national and international emergency response systems.
4. Establish bio-dosimetry network between KACST, KFSH&RC, local and regional cytogenetic laboratories and collaborate with IAEA and WHO to coordinate efforts in radiation accidents.
5. Provide platform for expert training and education in bio-dosimetry in Saudi Arabia and advance research to develop more efficient biomarkers of radiation exposure.

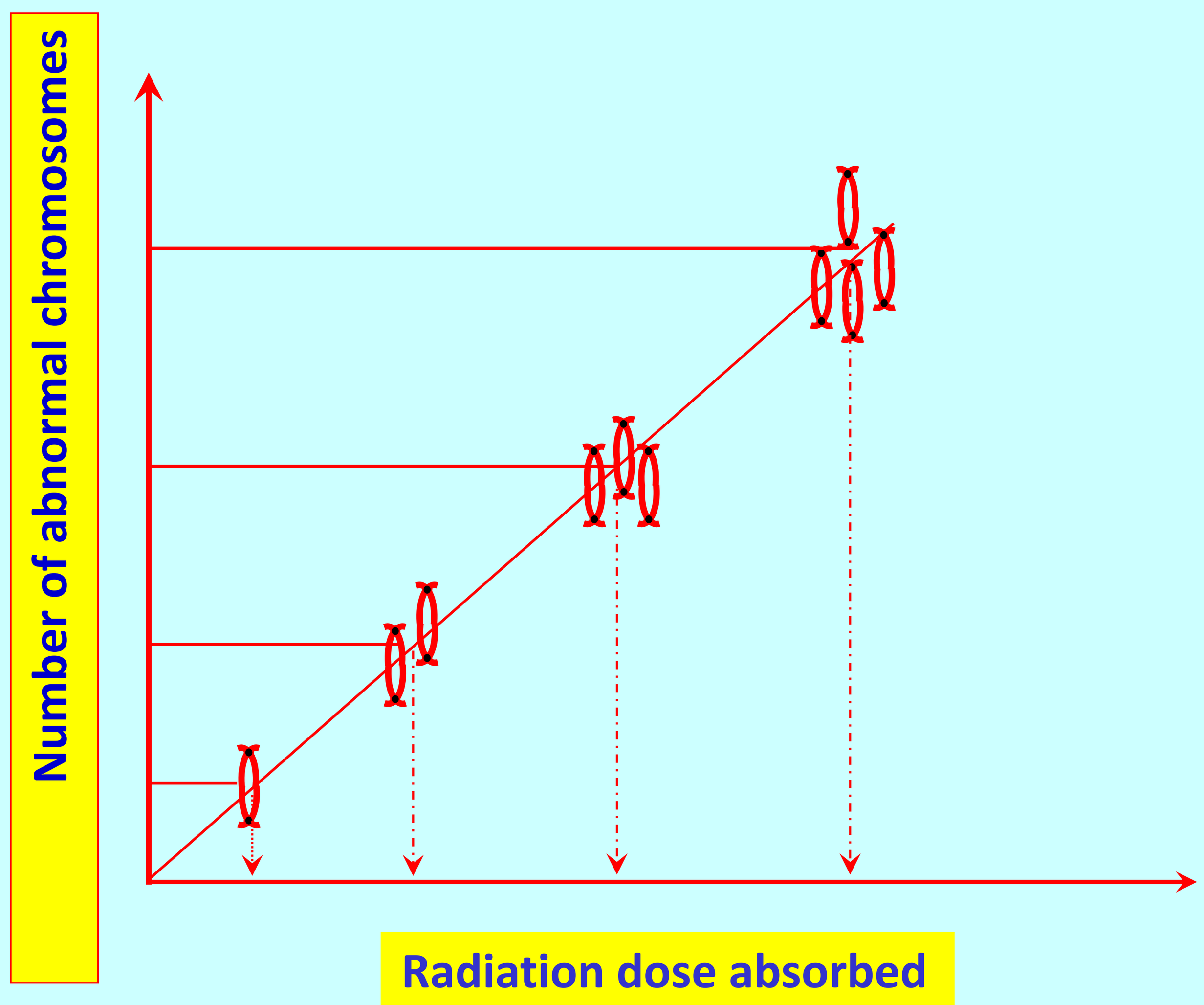
Methodology

Peripheral Blood Lymphocytes (healthy Saudi volunteers) → irradiation 0, 0.5, 3, 5 Gy → Cytogenetic slide preparation → Dicentric chromosomes' scoring

Fig. 1: Dicentric Chromosome present in a cell treated with Low Dose Radiation

Metafer 4 system for automated dicentric chromosomes scoring installed in the Radiation Biology laboratory at the Biomedical Physics Depart, KFSH&RC.

Fig.2: Radiation Dose is Determined By the Number of Dicentric Chromosomes Observed in Cells



Results

Table 1: Inter-cellular distribution of dicentric chromosomal aberrations after X-rays irradiation of blood in a Saudi volunteer.

Dose (Gy)	N. metaphases	N. dicentrics	D0*	D1*	D2*	D3*	D4*	D5*	D6*	Y
0	1229	11	1218	11	0	0	0	0	0	0.00895
0.5	1160	22	1138	22	0	0	0	0	0	0.01897
1	662	52	611	50	1	0	0	0	0	0.07855
3	502	219	324	142	31	5	0	0	0	0.43625
5	496	422	271	104	68	34	15	4	0	0.85081

N. metaphases: number of cells in metaphase assessed.
N. dicentrics: total number of dicentrics found in the cells assessed.
** Number of metaphases* with 0, 1, 2, 3, 4, 5, 6 dicentrics, respectively.
Y: yield of dicentrics, i.e. the number of dicentrics per cell (metaphase).

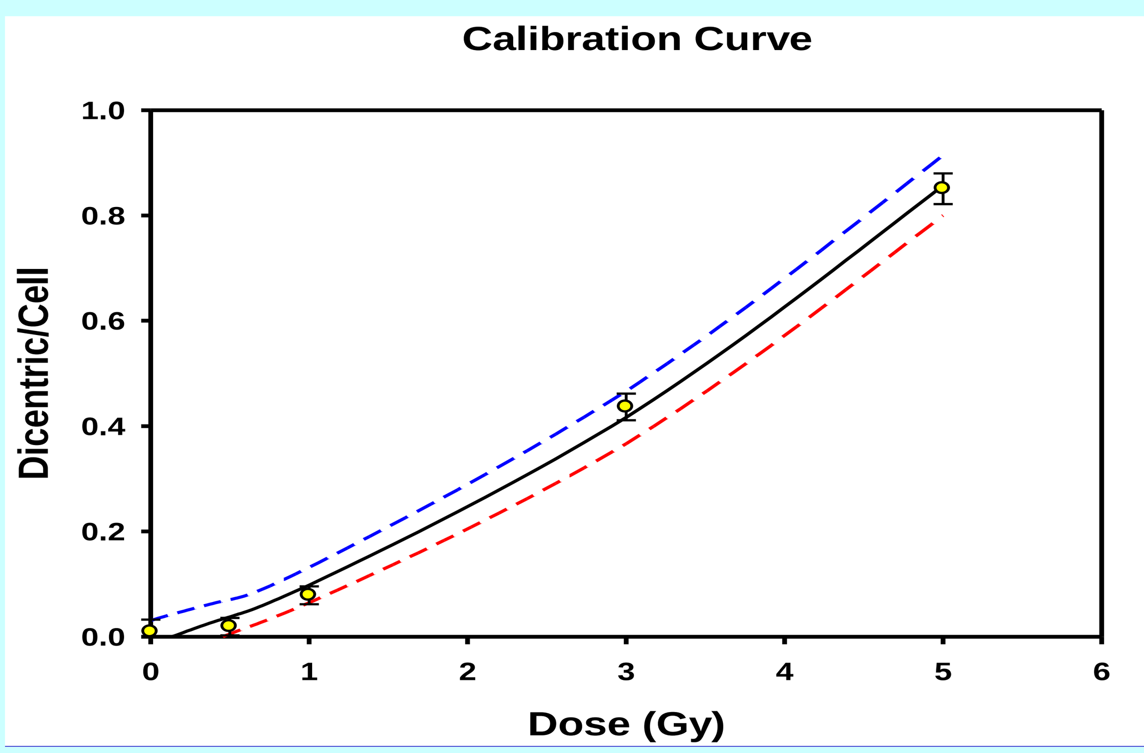


Fig. 3: Linear-quadratic standard calibration curve (solid line) for dicentrics induced in human lymphocytes by X-rays exposure (320 KeV, maximum photon energy is 1.3 Gy/min). Data points are the yield of dicentrics per metaphase analyzed. Error bars are the standard error of the yield. Dashed lines are the 95% confidence limits.

- The dicentrics chromosomal data were fit to the linear-quadratic dose-effect model:

$Y = C + \alpha D + \beta D^2$

where Y is the yield of dicentrics, D is the dose, C is the control (background frequency), α is the linear coefficient and β is the dose squared coefficient.

- The following equation was derived (± Standard Error):

$Y_{Dic} = - 0.015 (\pm 0.024) + 0.098 (\pm 0.029) \times D + 0.015 (\pm 0.006) \times D^2$

The resulting preliminary dose-response calibration curve for the induction of dicentric chromosomal aberrations in Saudi Arabia is shown in Figure 3.

Conclusions

- The dose response curve is comparable to those described in other population obtained by international laboratories.
- The activities of the biological dosimetry laboratory will provide information for decision-makers and public health officials who assess the magnitude of public, medical, occupational and accidental radiation exposures.
- The laboratory is setting cooperation with international biodosimetry network.