HOSTED BY

Available online at www.sciencedirect.com
ScienceDirect
Journal of Radiation Research and Applied Sciences
journal homepage: http://www.elsevier.com/locate/jrras

Evaluation of low dose ionizing radiation effect on some blood components in animal model

H. El-Shanshoury [a,b], G. El-Shanshoury [c,d], A. Abaza [e,f,*]

[a] Radiation Safety Department, Nuclear and Radiological Regulatory Authority, Cairo, Egypt
[b] Laser Sciences (Department of Medical Applications of Laser), National Institute of Laser Sciences, Cairo University, Cairo, Egypt
[c] Applied Statistic in Radiation Safety Department, Nuclear and Radiological Regulatory Authority, Cairo, Egypt
[d] Applied Statistic, Ain-Shams University, Cairo, Egypt
[e] Safety and Prevention of Oncology in Radiation Protection Department, Nuclear and Radiological Regulatory Authority, Cairo, Egypt
[f] Childhood Studies & Pediatric Oncology, Ain-Shams University, Cairo, Egypt

ARTICLE INFO

Article history:
Received 28 July 2015
Received in revised form
31 December 2015
Accepted 3 January 2016
Available online 14 January 2016

Keywords:
Ionizing radiation
WBCs
Platelets
RBCs

ABSTRACT

Exposure to ionizing radiation is known to have lethal effects in blood cells. It is predicted that an individual may spend days, weeks or even months in a radiation field without becoming alarmed. The study aimed to discuss the evaluation of low dose ionizing radiation (IR) effect on some blood components in animal model. Hematological parameters were determined for 110 animal rats (divided into 8 groups) pre- and post-irradiation. An attempt to explain the blood changes resulting from both irradiation and time is given. There was a significant reduction in WBC counts one day after irradiation at all dose levels compared to the control group and started to be affected at the dose of 0.3 Gy. The significance was increasing with increasing the dose. The degradation rate was 15 times higher than the recovery rate. Although both rates increase with increasing the dose, however, the rate of recovery in the second stage is faster than that in the initial stage. Platelet count shows a slow increase in the rate of recovery with increasing the dose up to 0.4 Gy. After which there is a linear increase up to a dose of 1 Gy with a slope of 21 count/day/Gy. Additionally, there is an increase in the rate of degradation on the applied dose up to 0.3 Gy with a slope of 61.6 count/day/Gy. The recovery rate of red blood cells count (RBC) increases with the increase in the dose reaching a maximum at about 0.5 Gy. Further increase in dose resulted in a rapid degradation with a minimum count at the dose of 0.75 Gy at the maximum value of 0.5 Gy, the change in count decreases exponentially with the increase in time.

The present findings suggest that damage from IR causes a significant reduction in blood cell counts in a dose-dependent manner, which may be considered a potential health

* *Corresponding author*. Safety and Prevention of Oncology in Radiation Protection Department, Nuclear and Radiological Regulatory Authority, Cairo, Egypt.
E-mail addresses: hala.elshanshoury@yahoo.com (H. El-Shanshoury), ghada.i.el-shanshoury@hotmail.com (G. El-Shanshoury), aya_abaza@hotmail.com (A. Abaza).

Peer review under responsibility of The Egyptian Society of Radiation Sciences and Applications.
http://dx.doi.org/10.1016/j.jrras.2016.01.001

risk during exposure to irradiation. Much effort must be done and focused on establishment of protocols for medical management of radiation injuries based on hematopoietic changes for biodosimetry.

1. Introduction

Living organisms are continually exposed to IR in nature as well as from nuclear weapons testing, occupations, consumer products, and medical procedures (Hall & Giaccia, 2008). The effect of exposure to IR is of interest to the space exploration community as well as patients considering radiotherapy (Sanzari et al., 2013a). Ionizing radiation (IR) damages biological tissues by exciting or ionizing their atoms and molecules. Depending on the exposure to radiation dose and the biochemical processes, damage may be prompt (expressed minutes to weeks after exposure) or delayed (expressed several months to years later) (Hall & Giaccia, 2008). Ionizing radiation (IR) has a sufficient amount of energy to induce physical symptomatology within minutes of exposure, appearing as the acute radiation syndrome (ARS). The prodromal phase of ARS includes nausea, vomiting, and fatigue. The quality of radiation, dose, and dose-rate are all contributing factors to the differential symptoms of ARS. These prodromal symptoms can be followed by dramatic decrease in peripheral blood cell counts, as hematopoietic cells represent a renewal system consisting of cells with fast division rates that are known to be sensitive to IR (Sanzari et al., 2013a). When cells are exposed to IR, they respond in a variety of ways that differ quantitatively and qualitatively according to the absorbed dose and the cell type that generally reflects damage caused to a well-defined cellular components and molecular structures (Holl et al., 2000). Chronic exposure of mammals to low dose-rates of ionizing radiation affects proliferating cell systems as a function of both dose-rate and the total dose accumulated. The lower the dose-rate the higher needs to be the total dose for a deterministic effect, i.e., tissue reaction to appear. Additionally, previously investigators published representative data on low dose-rate induced responses in the hemopoietic system that done on rat and dog. They observe that, the relationship between daily low-dose level exposures and clinical signs and symptoms in the exposed organisms is determined by the damage accumulating especially in the rapidly turning over cell renewal systems – such as the hemopoietic tissue. This means that the tissue effect of hemopoietic failure depends on both total absorbed dose, in short dose, and on the dose-rate or frequency of repetitive exposures (Fliedner, Graessle, Meineke, & Feinendegen, 2012).

Exposure to IR is known to have lethal effects in blood cells (Billings, Romero-Weaver, & Kennedy, 2014). Prior studies in mice demonstrated that the, lymphocytes, a type of WBC, show the most immediate response to IR by exhibiting a dramatic drop 24 h (one day) following radiation exposure, and then recovery occurs. In contrast, platelets decline more gradually, over a longer time period (Maks et al., 2011; Romero-Weaver, Wan, Diffenderfer, Lin, & Kennedy, 2013a). Additionally, the complications associated with the hematopoietic syndrome include infection and internal hemorrhage. The decrease in peripheral blood cell counts recorded within the first 48 h of radiation exposure serves not only as a marker for the severity of the exposure, but also as a marker for treatment and prognosis (Sanzari et al., 2013b). Unfortunately, at very low dose-rates, the total dose that is needed to bring about the tissue effect of hemopoietic failure reaches very high values, so that at low dose-rates hemopoiesis continues to fully function clinically up to very high total doses, as is explained also theoretically (Kutkov, Buglova, & McKenna, 2011). Thus, both total dose and dose-rates need consideration in evaluating radiation effects in red bone marrow. Limited data are available on the effects of varying dose-rates for a given accumulated dose (Fritz, 2002). On the other hand, the study of Sanzari, Cengel, Wan, Rusek, and Kennedy (2014) suggest that damage from IR causes a significant reduction in blood cell counts in a dose-dependent manner.

However, the mechanisms of the considerable tolerance to hemopoietic failure at low dose-rates are largely unknown but likely linked to stem cell responses (Fliedner et al., 2012).

The aim of the present study is to discuss the evaluation of low dose ionizing radiation effect on some blood components in animal model.

2. Material and methods

One hundred and ten male albino rats (*Rattus rattus*) were used in this study weighing 125–140 g at the beginning of the experiment. The animals were accommodated in plastic cages under controlled conditions of temperature, humidity and light and had free access to tap water and food. A specially designed cage was used for the purpose of irradiation; such cage is composed of two co-centric cylinders of 22 cm height such that the radius of the inner one is 16 cm while the radius of the outer one is 24 cm. The source is located at the center of the cage. The rats were kept between these two cylinders during the irradiation process which means that the rats are positioned at 20 cm from the source approximately.

Cesium-137 (^{137}Cs) gamma source was used for irradiation purpose. Such source is available in the National Centre for Nuclear Safety and Radiation Control (NCNSRC), Egyptian Atomic Energy Authority (EAEA). The dose rate of such source at 20 cm was 2.56 mGy/h at the time of the experiment which is in accordance with the dose rate recommended by the UNSCEAR 1993 for low doses.

The experimental animals included in the study were divided into 8 groups. First group which is the control group