The effect of thermal neutrons on samples of human blood

Mohammed K. Alfakhar

University of Wasit, College of Science, Physics Department

تاثير النيوترونات الحرارية على نماذج من دم الانسان

محمد قاسم الفخار

جامعة واسط - كلية العلوم - قسم الفيزياء

المستخلص

عندما يتعرض الانسان لأي نوع من انواع الاشعاع فان ذلك قد يكون مفيدا او مضرا ، مفيدا اذا استخدم الاشعاع لاغراض مفيدة ومعينة مثل الاستخدامات الطبية وضمن الحدود المسموح بها، بينما يكون ضارا اذا كان التعرض عشوائي وبجرعات اشعاعية تتجاوز الحدود المسموح بها.

ان تاثير النيوترونات الحرارية على نماذج من دم الانسان تم اختباره في هذا العمل، وقد حددت ودرست هذه التأثيرات على مركبات الدم مثل خلايا الدم الحمراء (RBC)، خلايا الدم البيضاء (WBC)، وتركيز الهيموغلوبين.

استخدم في هذا البحث ثمانية متطوعين (اربعة رجال واربعة نساء) وتم تحليل ودراسة هذه النماذج بعد تعرضها للنيوترونات الحرارية لفترات زمنية مختلفة. كان النموذج الواحد يتكون من (4cc)، حيث يتم تقسيم النموذج الى جزئين احدهما لتعريضه الى النيوترونات الحرارية لمدة ستة ساعات وهذه النيوترونات صادرة عن المصدر الحراري [Ra-Be] حيث يتم وضع نماذج الدم في انابيب خاصة من مادة البولي اثيلين، اما الجزء الثاني من النموذج فيستخدم كنموذج قياسي. تم اعادة عملية التعريض للنيوترونات لفترات زمنية مختلفة مثل (12hr, 18hr, and 24hr).

لقد وجد ان عدد وتركيز كل من خلايا الدم الحمراء (RBC)، خلايا الدم البيضاء (WBC)، وتركيز الهيموغلوبين تتاثر وتقل كلما زاد زمن التعرض للنيوترونات الحرارية (اي تتاثر الحالة الصحية للشخص عند تعرضه الى النيوترونات الحرارية)، كما وجد ايضا انه لايوجد فرق عما اذا كان المتطوع ذكر ام انثى عند التعرض الى النيوترونات الحرارية.

Abstract

Radiation can be either useful or harmful when human exposed to any kind of radiations. The effects of radiations on human blood samples were tested. In this study, blood was irradiated with Ra-Be (α, n) thermal neutron source. The effects on the components of blood (Red blood corpuscles, white blood cells, and hemoglobin concentration) examined and recorded.

The work undertaken focuses on the analysis of the blood sample after they had been irradiated. Four cc (4cc) blood samples were gathered from 8 different volunteers (4 males and 4 females). After that each samples was divided into two equal parts (1cc each) and placed in different polyethylene tubes, with the first to be used as a standard. The other sample were irradiated also for six hour using thermal neutron source Ra-Be (α,n). Afterward, new samples were taken from some volunteers, and the process repeated with different lengths of exposure to the radiation (12, 18, and 24 hours).

It was found that the number of red blood corpuscles, white blood cells, and hemoglobin concentration decrease the longer the samples are exposed to thermal neutrons. This trend was consistent with each volunteer's samples, and came regardless of whether they were male or female.

1. Introduction

The research of this paper will cover basic biophysical and biological effects of thermal neutrons. The nature and severity of these effects will depend upon a great variety of biological and physical aspects. Many researchers have investigated and studied the benefits and damages of radiation on humankind, and living organisms. Samples of human blood have been tested in this work.

Feurgard C. in 1998(1) worked on the effects of ionizing radiation (neutrons and gamma rays). Male Wistar rats were exposed to 4 Gy on (neutrons / gamma) rays radiation. After whole-body irradiation, plasma cholesterol and phospholipids levels increased up to 62% and 37%, respectively. On the other hands, plasma triglyceride concentrations decreased with the decreasing of food intake after irradiation but remained higher than in control rats. It was found that four days after irradiation, most of the measured cholesterol was transported by Apo lipoprotein E-rich.

Goes E. G. in 2006(2) determined the red blood cells radio sensitivity to thermal neutrons and ^{60}Co gamma rays. This work had been done to identify that the most appropriate dose for the prevention of transfusion-associated graft-versus-host disease, the radio sensitivity of the red blood cells have been determined in blood bags irradiated with X-rays produced by a linear accelerator, γ-rays derived from ^{137}Cs source of a specific irradiator, and thermal neutrons from neutron source Ra-Be (α,n).

The deformability and viability of irradiated red Blood cells were investigated by Roberto Reverberi in 2007(3). The irradiation of blood components with ionizing radiations was necessary to prevent the graft-versus host disease. In particular, red cells were damaged and have a decreased "in vivo" recovery, an increased "in vitro" haemolysis, and leakage of potassium in the supernatant. The results of the clinical studies showed that the loss of viability progressively increase with the storage after irradiation.

Yu-Kyung in 2008(4) studied the susceptibility of oxidative stress on red blood cells exposed to ionizing radiations. Irradiation induced kinds of biochemical changes in stored red blood cells (RBCs) and to generate reactive oxygen species. This study mainly evaluated the hemorheological properties, the degree of lipid peroxidation and the oxidative susceptibility of irradiated (RBCs). Red blood cells changes were more prominent in irradiated red blood cells than in non-irradiated red blood cells also under conditions of oxidative stress.

The effect of electron, thermal neutrons, and gamma irradiation on the induction of the micronuclei in cytokinesis-blocked human blood lymphocytes was investigated by Santhosh A. in 2009(5). This investigation had been done to understand the relative biological effectiveness in red blood cell of electron compared with thermal neutrons and gamma rays. The dose-response relationships for induction of micronuclei fitted well to a linear-quadratic relationship.

2. Experimental Arrangement

2.1 Neutron Sources

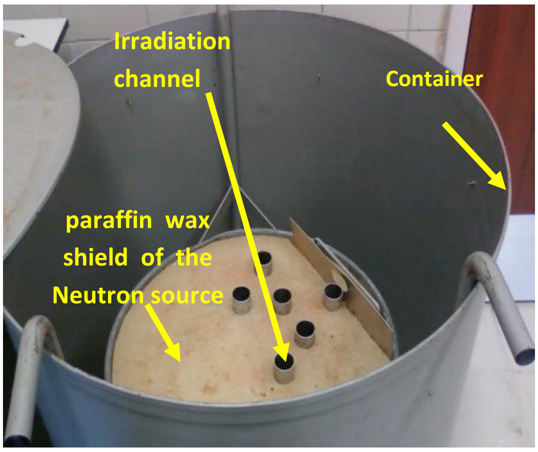
The most common laboratory neutron source is the Radium-Beryllium (^{226}Ra-Be) source. This consists of about five parts of Beryllium to one part of radium and makes use the reaction:

$$^{9}_{4}Be + \propto \; \rightarrow \; ^{12}_{6}C + ^{1}_{0}n + 5.5\; MeV$$

Due to the long range α's (7.68 MeV) from Radium decomposition products, the energy spectrum of neutrons obtained extends all the way up to 13 MeV. Slow neutrons are usually obtained by surrounding the source with paraffin as shown in Figure 1.

In this work, Ra-Be (α,n) thermal neutron source has been used. This source has an activity of 3 mCi and made by Leybold (55930). ^{226}Ra-Be : one curie *(1gm.) of Ra yields 10 to 15×10^6 neutrons / sec.

The disadvantage of this source is the strong gamma radiation from the Radium.



Figure(1):Radium-Beryllium source.

The Radium-Beryllium neutron source is enclosed in lead block and emits fast neutrons. The lead block is cast into paraffin wax block which serves as moderator and slows down fast neutrons to thermal velocities. Holes in the paraffin block at various distances from the source are provided for insertion of the substances that are to be activated by radiation.

The activity of the Ra-Be source: 111×10^{-6} S^{-1}, the total neutron flux is 30.000 neutron/second, and neutron flux density of thermal neutrons in the irradiation holes: approximately 100, 50, 25 neutrons per cm^2 and that is depending upon their distance from the source.

The energy of each irradiation hole is given by the formula:

The energy = N / (second.cm^2).

The energy = N * t (n / hour.cm^2)

Where N = (100 or 50 or 25), t is the time of irradiation, Size of the irradiation holes: approx. 30 cm long, and 3cm in diameter, Paraffin wax block: dia. approx. 40 cm, Outer distance shield: dia. approx. 80 cm, 91 cm high.

3. Factors affecting Experimental measurements

There are many factors indeed affecting the measurements of this work like background, and point isotropic sources consideration. These factors are discussed below:

3.1 Background and surrounding scattered radiation effects

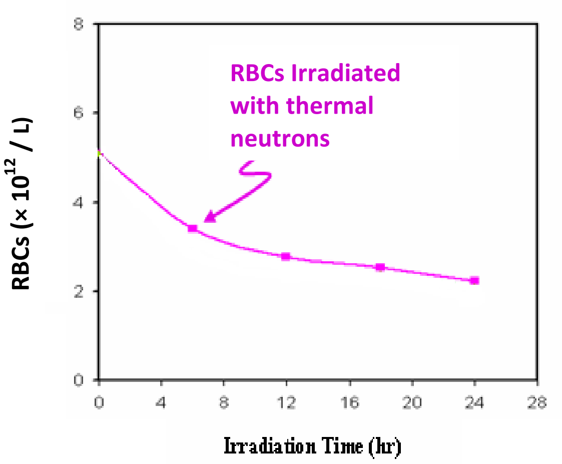
In experimental nuclear studies fields, the effect of background and surrounding scattering radiations must be subtracted from the counts and spectrum due to real measurements in order to determine the effects of certain radiation. This can be done by placing a good radiation absorber with an acceptable thickness. Another method may be used to determine the effect of background by removing the neutron source from the system and putting it in its place inside the source shield away from the detector. This assures that all primary radiations from the radioactive sources are absorbed and removed. The radiations that reach the detector are only those from the background and surrounding. Then the use of this arrangement will guarantee that the radiation reaches the samples do not include background and surrounding scattered radiation effects. This method has been previously used by several researchers (6,7).

4. Experimental Results and Discussion:

The analyzing reports of the samples for each person used to draw curves represent the effects of thermal neutrons on RBCs, WBCs, and hemoglobin concentration. Each curve represents the number of RBCs number, WBCs number, or hemoglobin concentration as a function of irradiation time. The drawing of the curves in this way makes the comparison of the effect on these factors easy and possible.

Figure 2 represents the effects of the thermal neutrons on RBCs number using many different irradiation time. While figure 3 represents the effect of thermal neutrons on the WBCs. The effects of the irradiation time on the WBCs follow the same conclusion as that of figure 2.

From figure 4, it is found that hemoglobin concentration reduction due to the effect of thermal neutrons is much less than the reduction of both RBCs and WBCs.



Figure(2): The effects of thermal neutrons on RBCs number using many different irradiation times

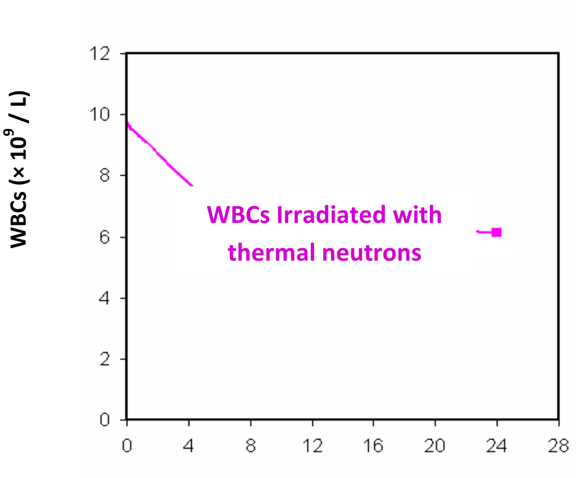


Figure (3): The effects of thermal neutron on WBCs number using many different irradiation times.

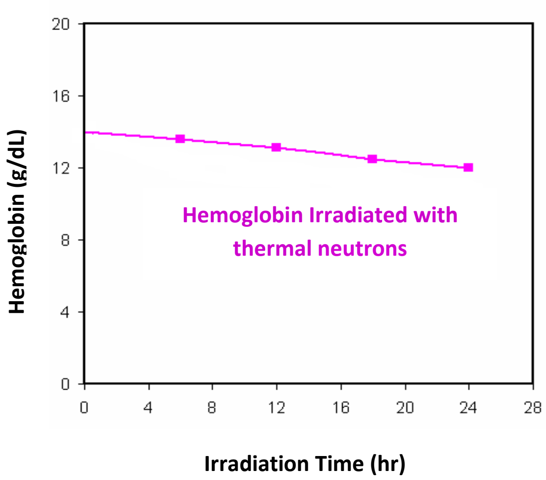


Figure (4):The effects of thermal neutron on Hemoglobin concentration using many different irradiation times.

The effects of whether the donor of blood samples male or female have been tested also by the determination for both samples the concentrations of RBCs, WBCs, and Hemoglobin. Both samples for male and female irradiated using thermal neutrons radioactive source to show that the sex has no effect on the reduction (both have approximately the same reduction).Figures 5 to 7 show clearly that the sex has no effects on the reduction of these factors after the samples have been exposed to the thermal neutrons.

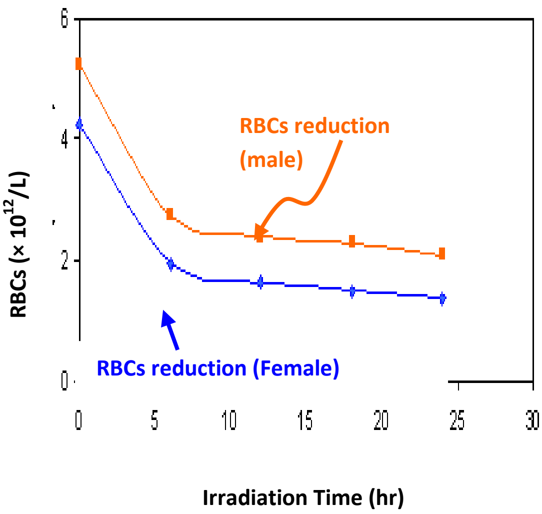


Figure (5): Comparison between the reductions of RBCs concentration after irradiation using thermal neutron radioactive source for both male and female

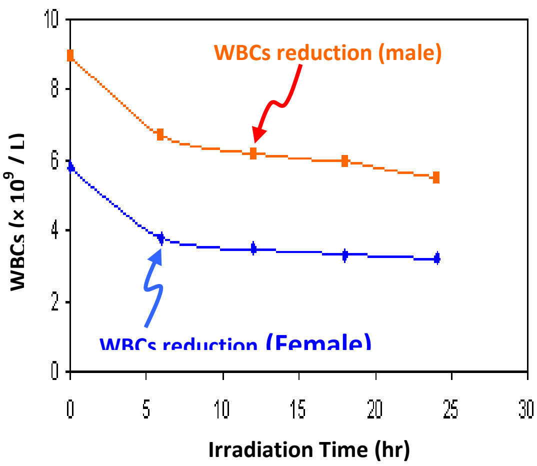
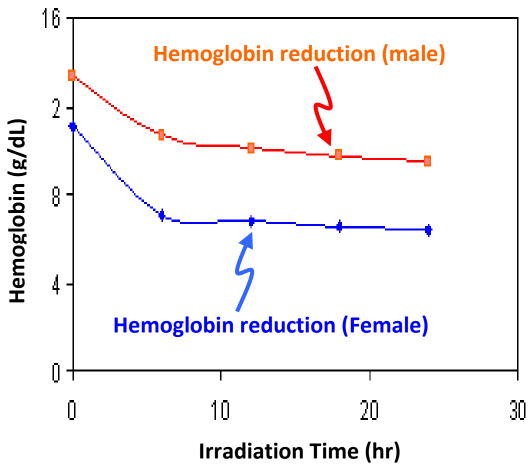


Figure (6): Comparison between the reductions of WBCs concentration after irradiation using thermal neutron radioactive source for both male and female



Figur (7): Comparison between the reductions of hemoglobin concentration after irradiation using thermal neutron radioactive source for both male and female

5-Conclusions

These measurements are found that the reduction of RBCs, WBCs, and hemoglobin concentrations measured after been exposed to thermal neutron was very clear. That is meant that the samples used are sensitive to radiation.

Another important investigation may determine the relation between sex (whether the donor was male and female) and the exposure to thermal neutrons. The results show clearly that there are no relations between radiation and the sex of persons who donated the blood samples. That is because both samples have the same reduction at the same irradiation time.

References

1-Feurgard C. (1998). Effects of Ionizing Radiation like (Neutrons and Gamma Rays) on Plasma Lipids and Lipoproteins in Rats", Radiation Research Society, 150: 43-51.

2-Goes E., Borger J., Covas D., Orellana M., Palma P., Morais F., and Pela C. (2006). Determination Red Blood Cells Radiosensitivity to ^{60}Co Gamma Rays, Transfusion, 46(1):34-40.

3-Roberto R., Maurizio G., and Marina V. (2007). The formability and viability of irradiated red Blood cells, Ann 1st Super Sanita.43(2):176-285.

4-Yu-Kyung. (2008). Susceptibility of Oxidative Stress on Red Blood Cells Exposed to Gamma Rays, Clinical Hemorheology and Microciru-lation.,40:315-324.

5-Santhosh A., Ganesh S., Bhat N., Siddappa K., and Narayana Y. (2009). The effect of electron and gamma irradiation on the induction of micronuclei in cytokinesis-blocked human blood lymphocytes", Radiation and Environmental Biophysics. 48:197-203.

6-Diavisson C. M. and Evans R. D. (1950). Determination of linear absorption coefficient and relaxation lengths of air using Co-60 and Sc-137 gamma radioactive source,Phys. Rev., 81:404.

7-Kane P. P., Basavaraju G. and Varier K. M. (1977). The Effect of background and Surrounding scattering radiation using a Good gamma absorber, Nucl. Instr. Meth., 147, 507.