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SOME DATA ON THE CONDITION OF RABBITS AFTER MASSIVE WHOLE BODY X-IRRADIATION I. GROWTH RATES AND SPLEEN INDICES

A.R. FIKRY HASSAN* AND MADIHA ASHRY

X-Ray Laboratory, Department of Physics, University of Kuwait

Abstract . The X-ray Unit of the Department of Physics at the University of Kuwait has been utilized to investigate the effects of massive whole body X-irradiation, using Albino Chichilla rabbits. The effective energy of the X-radiation was determined by experimentally constructing the absorption curve in aluminium. The value of this physical parameter was needed in order to evaluate the total radiation dose used in the present investigation. The effects of the X-irradiation on both the animal growth rates and the spleen indices were investigated and compared with the findings of other workers.

INTRODUCTION

In the last few years, an increasing number of reports have appeared on the biological effects of whole or partial body X-irradiation with doses of different strengths. Nevertheless, the acute exposure of mammals to sublethal irradiation dosages is not extensively documented and, with few exceptions, is restricted to mice.

This paper, the first of a series, describes some aspects of the methodology common to all the studies, with a special note on the radiation dosimetry. Comparative results of the growth rates of the experimental and control rabbits as well as estimates of their spleen indices are presented.

MATERIAL

The animals employed in this investigation were 24 Albino Chichilla rabbits, six weeks of age, averaging 550 g of body weight at the commencement of the experiment. They were accurately weighed within ± 2.5 g, then divided into two groups : experimental group, consisting of 18 rabbits, and control group, consisting of 6 rabbits. Rabbits of both groups were offered a complete synthetic diet (manufactured by Al-Homaizy Cattle and Poultry Food Factory, Kuwait). This is a well-balanced diet in the form of commercial pellets. The ingredients, together with the percentage in weight of each dietary component are given in Table 1. This diet supplies the animal with the basic requirements summarized in Table 2. In addition, drinking water and green leafy vegetables were also supplied daily.

TABLE 1. Composition of the diet given to both the irradiated and the control groups of rabbits employed in the present experiment

Ingredient	%
Wheat, whole ground	50
Barley, whole ground	25
White fish meal	7
Meat and bone meal	6
Dried Brewer's yeast	5
Dried grass meal	5
Cod liver oil	1
Salt	1

TABLE 2. Nutritional components of the diet given in Table 1

Component	%
Moisture	14.3
Carbohydrates	53.4
Protein	20.0
Fat	3.8
Fibre	3.3
Ash (Ca : 0.7 , P : 0.8)	5.2

*Present address : Department of Physics, Faculty of Science, University of Ain Shams, Cairo, Egypt.

METHODS

a — Irradiation Procedure. The X-ray source used in the present experiment was the Philips Unit of the Department of Physics, University of Kuwait. (Type : PW 1352/10). The physical characteristics of the exposure were as follows : voltage: 40 KV; current: 20 mA; filter: none. During irradiation, rabbits were individually housed in a special wooden box lined with lead (25 x 17 x 15 cm). The distance between the X-ray window and the midline of the animal was on the average 17 cm. The effective energy of the X-radiation continuum was found to be 9.5 Kev. This value was determined by carrying out absorption measurements of the X-radiation in aluminium, using standard foils supplied by the Nuclear Chicago Company, and a radiation meter, Type FH 55B. The resulting absorption curve is presented in Fig. 1. From this curve a

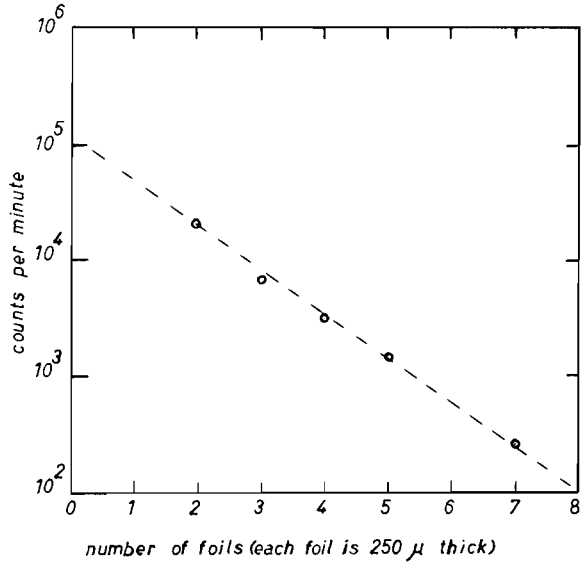

FIG. 1. The Absorption in Aluminium for the X-radiation continuum used in the present experiment

value of 32 was obtained for the linear absorption coefficient, α'. This corresponds to the effective energy value cited above, viz., 9.5 Kev. Table 3 is reproduced from Casarett (1968) and was used for the interpolation needed. Each rabbit was irradiated, over a period of 5 minutes, with a total radiation dose of 1500 roentgens.

TABLE 3. Variation of the linear absorption coefficient, μ_{Al}, with the energy of X-rays (From Cassaret 1968).

μ_{Al} (cm^{-1})	20	25	30	35	40
E_x (Kev)	14.4	13.4	12.7	12.2	11.6

b — Study Methods. A weekly record of the body weights of each rabbit was made. Rabbits from both groups were killed successively, at weekly intervals, between the first and the fifth week. This was done by ether inhalation and complete autopsies were performed. Spleens were removed by careful dissection, and fresh spleen weights were determined to the nearest 10 mg. Spleen indices* in units of mm^2, were measured according to the method introduced by De Witt *et al.* (1959). Spleen and all other organs manifesting any abnormality were then formalin-fixed for further studies and these will be reported in a forthcoming communication.

RESULTS

a — Growth Rates. The average body weights of both the non-irradiated controls and the irradiated rabbits are shown in Fig. 2. The irradiated animals stopped growing after one week

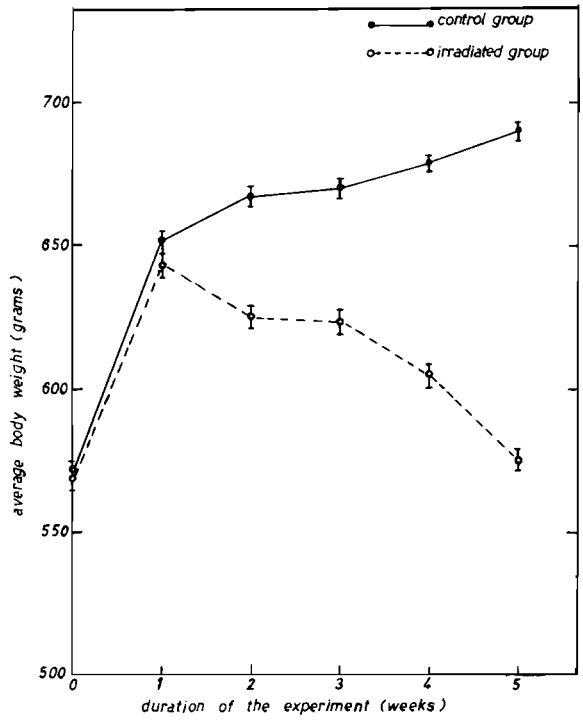

FIG. 2. Effect of Massive X-irradiation on average body weight

* This parameter is calculated by multiplying the length of the spleen by its average width and is expressed in mm^2. Since then, spleen index has been considered as one of the most important etiological factors in spleen diseases.

and from then on lost weight. It should be noted, however, that slight individual variations as to the amount lost by individual rabbits existed, though they always followed a more or less similar trend. During the overall experimental period of five weeks, the irradiated group showed an average weight gain of only 0.8% of their initial body weights, compared to 21% for their controls.

Two out of the 18 irradiated rabbits died on the 11th and 20th days.

b — Spleen indices. Spleen indices of the control rabbits showed slight individual variations with an average of 200 mm^2. By comparison of these values with those of the irradiated group (Fig. 3)

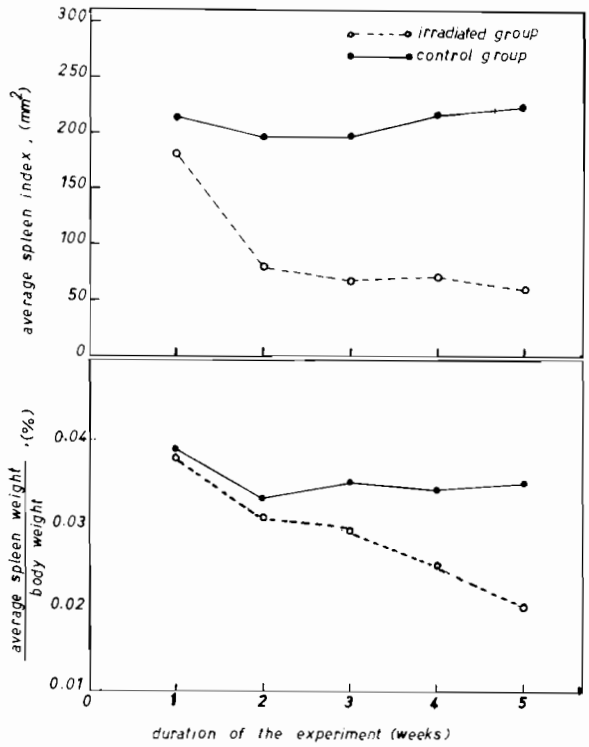

FIG. 3. Effect of Massive X-irradiation on the Spleen

it is evident that X-irradiation had a significant effect on the spleen index. Considerable regression was noted by the second week, and continued progressively until the end of the experiment where the spleen index was only 35% of that seen normally.

In order to obtain a more precise measure of the splenic changes under the condition to be innvestigated, spleen weights were plotted as a function of the body weights of rabbits, viz., (spleen weight/body weight) × 100, (Fig. 3, lower part). The relative spleen weights of the control group showed an almost uniform value (average 0.038 per cent). With the progressive growth retardation of the irradiated rabbits from the second week on, a dramatic decline in the relative spleen weights was also noted, where an average of 0.02 per cent was commonly observed.

Discussion

The acute radiation syndrome obtained after whole body X-irradiation of rabbits with 1500 R, a dose approximately double the LD_{50}, was characterized by a variety of morphological changes, most obvious of which was retardation of growth (Bregadze 1966). The marked drop of the body weights of irradiated rabbits and the mortalities observed during the second week are in agreement with earlier estimates which indicated a marked increase in the radiation sickness syndrome in Syrian hamster (Holloway *et al.* 1968), in mice (Liberman and Sakovskaya 1967), and in rabbits (Bregadze 1966) during the second week. A mechanism responsible for growth impairment cannot be delineated on the basis of these results. However, there is mainly negative evidence for the possibilities of either a nutritional disturbance with respect to food intake (Sohsaka *et al.* 1969), or a disturbance of well known endocrine functions (Mosier *et al.* 1970).

Since the time Jacobson *et al.* (1969) found that spleen shielding improved survival of mice exposed to whole body ionizing radiation, morphology and physiology of the spleens of irradiated animals have been studied extensively. In many of these studies, the spleen of an irradiated animal has been used as an 'in vivo' chamber in which morphologic functional characteristics of endogenous or exogenous cells could be examined. Because rapid restoration of haemopoietic tissue is required to prevent acute deaths of irradiated animals (Smith and Congdon 1960), and because it is well established that the spleen participates in haemopoietic regeneration, loss of a portion of haemopoietic space of the spleen i.e. shrinkage, might then be expected. Smith and Alderman (1955) suggest that such shrinkage may be related to stress reactions which improve defence against infection. Other workers have also noted a significant decrease in the spleen size (Wang and Ma 1965), spleen weights (Avetison 1967) and also marked shrinkage of the different cell types (Jordan 1967) of the spleens of irradiated rats, though no further explanation was offered.

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بعض البيانات عن حالة الارانب بعد تعريض أجسامها للاشعاعات السينية

الجزء الاول : معدلات النمو ومعاملات الطحال

عبد الرحمن فكري حسن* ومديحة عشري

قسم الفيزياء بجامعة الكويت

خلاصـــة

استخدم جهاز الأشعة السينية الموجود بقسم الفيزياء بجامعة الكويت لدراسة آثار تعريض أجسام حيوانات التجارب لجرعات كبيرة من الاشعاعات السينية . وتم هذا البحث على فصيلة الأرانب « الششيلا البيضاء » . وتم تعيين القيمة الفعلية لطاقة الاشعاعات السينية المستخدمة في هذا البحث بدراسة تغير الامتصـــاص في مـادة الالومنيوم لتلك الاشعاعات ، وهذه القيمـة مطلوبة لحساب الجرعات الاشعاعيـة التي عرضت لها حيوانات التجارب في هذا البحث . ولقد درست آثار الاشعـــاع السيني في كل من معدل النمو في حيوانات التجارب وأيضا على معامل الطحال لتلك الحيوانات وقورنت نتائج هذا البحث بنتائج المشتغلين في هذا المجال .

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* العنوان الحالي : قسم الفيزياء بكلية العلوم بجامعة عين شمس بالقاهرة