COMBINED ACTION OF RADIOACTIVE PHOSPHORUS AND SOFT-X-RAY ON WHITE MICE

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ABSTRACT

The effects of X-ray and radioactive phosphorus on life span of mice have been studied. It has been found that very minute doses of external and internal radiations when they are applied in combination can lead to death of experimental animals by the summeted biological damage produced by the radiations applied. But these minute doses individually are incapable of producing any detectable biological damage when they are applied separately.

INTRODUCTION

Ionising radiations from X-rays and from radioactive isotopes are widely used for clinical and experimental purposes. Generally soft X-rays (with low kv) are used for radiological diagnosis and hard X-rays (with high kv) are having theraputic importance. Similarly radioactive isotopes *viz.* Phosphorus, Iodine, Iron, Gold etc., are used in very small doses for diagnosis by tracer technique and again these isotopes in large doses are being used in treatment of diseases.

Radioactive phosphorus (P^{32}) is one of the radioisotopes that has been used in therapy[1,2]. When it is injected either in human being or animals there is a continuous internal irradiation due to the deposition of P^{32} in the various parts of the body.

Hevesy[3] and Chaikoff and Zilversmit[4] have summerised the relative concentration and the time variation of the concentration of P^{32} in different organs of experimental animals. Mitra *et al*[5] have shown the changes in the cellular elements of blood following the administration of different doses of P^{32}. Radiation due to deposition of radioactive isotopes in different organs produces biological damage in different systems of the living body. Degree of damage depends upon the dose of radioisotope applied. P^{32} with the dose of 4·5 micro curie per gram of body weight of rat was found to be lethal[6].

Evens and Quimby[7] claimed that reduction of white and red blood cells, shortening of the life span in mice are of similar nature when the whole body irradiation was done either by radiosodium or by roentgen ray. By the experiments of Rajewsky and others [8] on whole body irradiation of mice by Radium and X-rays with the varying doses from 250 r to 19,000 r, it is proved that the resultant effect on shortening of life span is dependent on both the amount of the complete dose and the dose rate. Systematic work on the mechanism of biological effects of ionising radiation has been reviewed by Hollaender[9].

In the presert experiment studies have been made on the effect of soft X-rays on life span of white mouse primed with the radioactive phosphous given in single minute dose of 0·157 micro curie per gram of body weight.

EXPERIMENTAL

12 white mice of 130 days old having the body weight ranging from 17 grams to 20 grams were taken and for a few days they were kept on balanced diet with water and libitum. Then the mice were divided into two groups of six each. Animals of one group were used as control and each of six of the other group were injected with P^{32} interperitonially with a single dose of 0·157 micro curie per gram of body weight. For this experiment carrier free P^{32} in isotonic solution was supplied by Atomic Energy Establishment, Trombay, Bombay. Just before the injection the strength of P^{32} was rechecked with the help of halogen quenched end window type Geiger Muller Counter with 15 mg. per Cm^2 as the thickness of the window. After 30 days each mouse received 15·6 rads as whole body irradiation due to internally deposited radioactive phosphorus. During this period of internal irradiation, the weight of the animals were checked at regular intervals and after 30 days it was found that there was a loss of weight by 3 to 4 grams in each experimental animal. Then the mice were exposd to external radiation from soft X-rays. For external radiation, Army field type 'Picker' X-ray machine was used. The x-ray head had a built-in 0·25 mm. aluminium filter. The machine was operated at 65 kv. with 12 milliamps. The measuring instrument was M/S Phillips ionisation chamber 37,480/00 with Philips dosimeter 'Metalix'. A paper sheet was placed just below the window and the position of the window was marked on the paper. The X-ray head was then slowly raised to a height of 25 cm. from the paper sheet and clamped. The window then fitted with cone with the help of apperture plates the proper apperture of the window was selected to give uniform field over an area extending to 10·2 cm. As there was inherent filtration, no other filter was used. The sensitive volume of ionisation chamber was placed in the middle of the area and the machine was operated at 65 kv. with 12 milliamps. Corrections were made for atmospheric temperature and pressure. A dose rate of 88 roentgens per minute was recorded in the marked area. The observations were repeated for number of times and the mean value of the dose rate came out to be 90r per minute.

As the animals were to be irradiated in a Pyrex glass capsule of 3·9 cm. diameter, and as not only the surface dose but the depth dose is also necessry, it was proposed to prepare a phantom to evaluate the dose correctly. The ionisation chamber was placed inside the cavity of the phantom so that its sensitive volume is well with in the phantom. A dose rate of 50 roentgen was recorded inside the phantom. Thi s gave the ratio of between the outside and the inside radiation field which came out to be 1·8. As a check the current in the X-ray tube was lowered and again the ratio was calculated which came out 1·78 this time which showed the reproductability of the value of the ratio. The animals within the glass capsule were irradiated in the same geometrical condition. The geometry was fixed by marking the position of phantom on the paper sheet.

Arrangements were made for uniform whole body irradiation and to facilitate breathing two holes were made at both the ends of the capsule. Materials of high stomic weight were kept away from the machine to minimise the back scattering. Before operating the machine each mouse to be irradiated was kept in the capsule and was placed in the position of irradiation for at least one hour for conditioning the animal inside the capsule. As the machine could only be operated for a short period of time, the irradiation was done at regular intervals. The machine was adjusted in such way that every shot of irradiation of eight seconds duration can deliver six roentgens of X-ray. After every exposure the machine was given one minute rest to avoid the X-ray tube to blow off. This type of intermittent exposures were continued till the desired effect of the external radiation was reached.

RESULTS

The radioactive phoshorus was injected interperitonally and the dose delivered by P^{32} in each mouse in 30 days is calculated with the formula[10] :—

$$D = 88\,E\,TEC\,(1 - e^{-\lambda Et})$$

$$= 88 \times 0{\cdot}6 \times 10{\cdot}82 \times 0{\cdot}157 \left(1 - e^{\frac{-0{\cdot}693}{10{\cdot}82} \cdot 30}\right)$$

$$= 52{\cdot}8 \times 1{\cdot}699 \times 0{\cdot}174$$

$$= 15{\cdot}6 \text{ rads}$$

(total body irradiation due to internally deposited radioactive phosphorus)

E=mean energy of beta rays in Mev.

T_E =effective half life in days.

C=quantity of isotope in micro curie/gram of body wt.

λ_E =effective decay constant.

t=period of irradiation in days.

After receiving 15·6 rads the animals were exposed to roentgen rays for whole body irradiation from external source. It is found that each experimental animal died immediately after receiving 32 r to 36 r of soft X-rays and each mouse of control group could tolerate whole body irradiation with 1,000 r of soft X-rays.

DISCUSSION

From the experimental and pathological studies it is proved that in the living body many a changes like gastro-intestinal damage, bone marrow atrophy, hormonal and biochemical changes and by issue lesions bacterial or viral infection may occur by ionising radiations.

When there is gastro-intestinal damage by high level radiation 3 to 5 days after the exposure death is preceded by vomiting and diarrhœa. Radiation injury of hematopoietic system (Consisting of bone marrow, spleen, thymus and lymphatic tissue) cannot cause the early death of the individual because circulating blood cells are quite sufficient in number to maintain the life for a week or more and ultimately death occurs due to the development of leucopenia or anemia.

According so Bacq and Alexander[11] a single exposure of 400 r to 700 r of X-ray can cause the death of mice after 30 days of exposure and the dose beyond 100,000 r death is instantaneous due to the destruction of large number of essential substances required for basic chemical activity to maintain the life, it is termed as 'molecular death'.

From the present experiment it appears that P^{32} in small dose of 0·157 micro curie per gram of body weight can produce some of biological damage, which cannot cause the death of mouse but to a large extent can lower the lethal dose of X-rays for instantaneous death.

Acknowledgements—Authors are grateful to Lt. Gen. B. M. RAO (RETD) Director of this Institute and Lt. Col. S. K. MAZUMDAR, A.M.C., Adviser-in-Radiation Medicine for their kind interest and encouragement throughout the work.

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