LARGE RADIATION EXPOSURE

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ABSTRACT

A case of large inadvertant radiation exposure to a person concerned with the replacement of a decayed ^{60}Co source by a new source in a telethera-py unit is described. An estimated exposure of 800 rads was received by the person while pushing the source in the source head of the unit with the hand in the vicinity of the source itself. The case history is discussed.

INTRODUCTION

A high radiation exposure took place in May 1967 at Safdarjang Hospital, New Delhi due to a planned deviation from an accepted procedure. This involved an acute local exposure to the hand far beyond the limits of maximum permissible doses to the hand and the skin[1].

^{60}Co SOURCE TRANSFER AND EXPOSURE

The loading, shipping and replacing sources by means of the Atomic Energy of Canada Ltd. 'Drawer' system ensures adequate simplicity and complete safety in all phases of source handling. The source shipping and transfer container has two drawers known as source drawer and dummy drawer. The cobalt beam therapy source is locked in the source drawer in a cavity in the center of a solid lead or lead-tungsten alloy drawer during the shipping and the transfer phase. The source head and the transfer container are aligned and the decayed source is withdrawn in the slot of the shipping container in place of the dummy drawer. Immediately after this, the new source is inserted as per usual procedure in the source head of the equipment.

However, it was observed that the source was not sliding into the source head probably due to disturbed alignment. It was at this time that a worker planned specially to insert the source manually by wearing lead gloves in hands as the only measure for radiation protection. The person who received large exposure had to hold the source drawer for a short time with his right hand palm in contact with the unshielded side of the source fixed in drawer itself. Thus the source in the source drawer was manually inserted in the source head without involving any other accident. It appears that the

hand of the person with complaints of the radiation burn received a heavy instantaneous localised exposure of 8000 rads during the span of 10 seconds.

ESTIMATION OF DOSE

We are interested in the estimation of the dose in the vicinity of the source which has to be therefore of finite size and the decrease of intensity is to be less rapid with distance in comparison to the case for a point source. As the irradiated hand has been covered with lead gloves and kept in contact with heavy solid medium of high atomic number and the surface of the sealed source, it appears therefore that the uniformity of the dose in the palm skin and its vicinity will be limited by inherent characteristics of the radiation source and the medium in contact with the skin.

Exposure to the hand in the geometrical confine of the beam approximates to the case of uniform irradiation of class A^2. The portion of the hand irradiated by the direct beam specifically in the geometrical confine of the beam should have received a uniform dosage mainly due to high quantum energy of the cobalt gamma radiation and due to thinness of the object irradiated. We may approximately calculate exposure at the mid point of the thickness of the irradiated site according to the inverse square law if we do not consider contributions from the scattered photons or the bremsstrahlung from the source and its surroundings. Exact amount of dose in the vicinity of the source would largely depend upon the duration of exposure and the distance of the hand from the source. An approximate evaluation of the dose rate at a distance of 3 cm from the source surface to the center of the hand along the axis of the beam is as follows:

Exposure rate in air at one meter from the source	= 45 R/min
Dose rate in air to small mass of soft tissue at 3 cm from the source	= 800 rads/sec

A detailed and accurate distribution of the dose in the confines of the beam and around it is under study and would be reported later on.

BRIEF POST-EXPOSURE HISTORY OF THE CASE

The person having received high exposure during the source transfer, complained about radiation burn within two weeks of the incident. He complained just after the source transfer a feeling of burning in the affected right hand which disappeared by the same day. Later his exposed hand did not give any feeling of inconvenience for about one week. Suddenly, after twelve days of exposure, he complained about tremendous burning sensation, itching and pain in the palm of the affected hand. He had been therefore hospitalised for about two days where his hand was given hot water fomentation. Immediately after discharge from the hospital, he developed a big boil of reddish colour at the place of the exposure giving unbearable pain and burning sensation. Some temporary relief was obtained when the boil was opened. However, thereafter his hand had been under various types of treatments at various places which involved plastic surgery and physiotherapy.

RADIATION EFFECTS

In the present case, there appears to be negligible exposure to the gonads and as such we will not consider hazards from a genetic stand point. As is well known the radiation effects can be classified into several categories depending upon the magnitude of the dose, extent of exposure, etc. They can be acute, chronic or acute-chronic effects.

The case under reference appears to have received therefore an acute and chronic exposure. In the above case, it is interesting to note that acute radiation effects would be pronounced firstly due to short period of time involved and secondly due to extremely large amount of local exposure which is even far beyond the normal tolerance level of skin and subcutaneous tissues of human beings. This influence of dose rate applies particularly to radiations of low LET which are commonly encountered in occupational exposure at the present time.

RELATIVE INTEGRAL DOSE

We have shown earlier[3] that relative integral dose (to be referred subsequently as R.I.D.) instead of the whole body integral dose could be a better choice for explaining patient's reaction in a course of radiotherapy. On similar grounds, we can define R.I.D. in the present case as follows:

$$\text{R.I.D.} = \frac{\text{Integral absorbed dose delivered to the whole body of a worker for a given set of conditions}}{\text{Integral absorbed dose to the tissues in the geometrical confine of the radiation beam for the same set of conditions.}}$$

The R.I.D. in the present case, would approximate to unity because whole body exposure is negligible in comparison to the local high exposure. This is the minimum possible value of the R.I.D. as per its definition in any case of localised exposure. It corresponds to the minimum general clinical reactions as a result of local exposure. We have earlier encountered values of R.I.D. to be around 6 in the treatment of carcinoma oesophagus by ^{60}Co teletherapy by two pairs of opposing fields at right angles to one another planned for a tumour lethal dose of 6000 rads in six weeks.

Hence local acute effects are mainly due to high exposure at a high dose rate. This acute somatic injury is therefore related to a causative radiation exposure.

CONCLUSIONS

It appears to be a case of acute and chronic exposure. The manifestation of acute effects is such that the relationship to the causative radiation exposure is obvious. The low value of R.I.D. confirms absence of general clinical reactions as a result of exposure. The severity of local effects is likely to show up also in terms of late effects.

It would be interesting to study chromosomal aberration frequency in order to confirm the present estimate of dose. In man, the extrapolation of chromosome aberration to dose can be made from the peripheral blood lymphocyte/leucacyte system[4,5].

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