LETHALITY OF UPPER BODY EXPOSURE TO X-RADIATION IN BEAGLES

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CONTROLLED lethality experiments are necessary as baselines in any study of specific reactions of a given species to ionizing radiation. As part of a program designed to delineate the biological response of the adult beagle to partial body irradiation, the LD-50/30, with the lower portion of the body shielded, was determined. For comparison with earlier investigations in this and other laboratories, another series of animals was subjected to whole body irradiation using similar techniques.

Materials and Methods

Test Animals

Ninety-five purebred beagles of both sexes weighing between 5 and 15 kilograms were used in these experiments. All animals were obtained from reputable sources and quarantined for at least 14 days for evaluation and standardization. Daily weights and rectal temperatures were obtained on at least 4 consecutive days prior to irradiation. Three or more preexposure hemograms were obtained on all animals. No animal was used in this study if abnormalities were found on complete physical examination or if clinical or laboratory data indicated any deviation from normal.

Using Anderson and Gee's criteria (*1*), which state that the beagle is fully mature by 3 years of age but that it attains adult blood values by 1 year, adult dogs were used. Mature adults (older than 36 months) were grouped with young adults (9–36 months) as far as possible, as dictated by their availability. A few animals 9–11 months of age were used since mature animals were not consistently available. The age distribution was as follows:

Age (months):	*Number animals*
9–11	11
12–24	50
25–36	1
37–48	11
49–60	13
60 and over	9
Total	95

Shielding and Dosimetry

Special segmental lead shielding was designed and fabricated. This shielding transmitted less than 1 percent of the air dose. When the X-ray beam was aimed directly across the opening of the shielding, varying amounts of radiation were scattered into the

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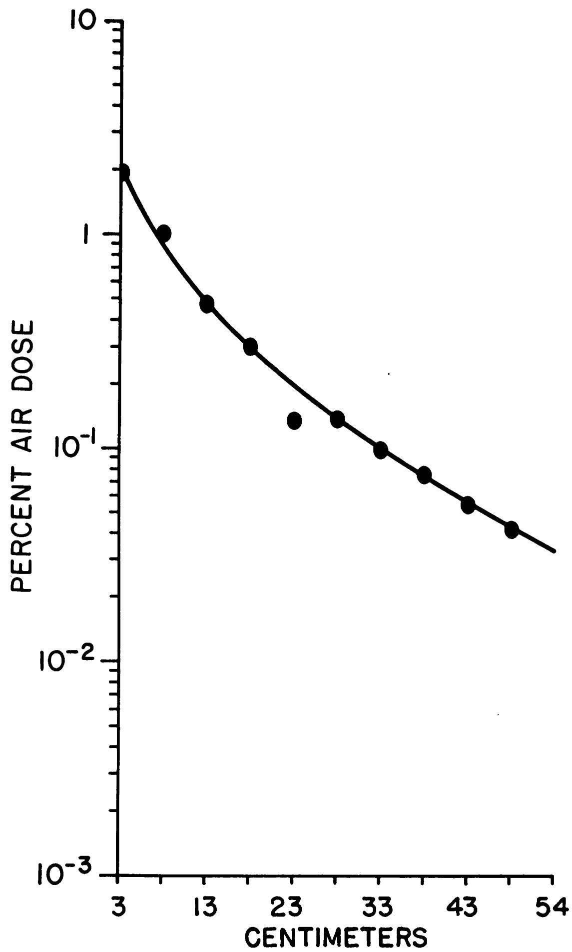
This paper is based on work performed under contract with the U.S. Atomic Energy Commission at the University of Rochester Atomic Energy Project. The views expressed are those of the authors, not official views of the U.S. Air Force.

shielded cavity depending on the position of the detector. The amount of scattered radiation as a function of depth within the cavity is shown in figure 1. When an animal was placed in position, more radiation was scattered into the shielded portion. Cadaver measurements indicate the pelvis of the animal received approximately 5 percent of the incident dose. This is in agreement with results obtained in partial body experiments in mice and rats (*2,3*) and chicks (*4*).

An industrial X-ray generator operated at 1,000 kvp. and 3 ma. with only inherent filtration was used for exposure. The half-value layer was 3.0 mm. of lead. The dose rate at 1 meter measured in air with a condenser roentgen meter was 50 r for the first minute and 65 r for each succeeding minute. Tests for the uniformity of the exposure field were made with a condenser roentgen meter together with silver activated phosphate glass microdosimeters (*5*). Cadaver depth-dose measurements were also made using this technique.

Figure 1. Scattered radiation as a function of depth within the shielded cavity



The irradiation field was found to be essentially uniform. Variation from midpoint to the extremes was less than 10 percent. Cadaver depth-dose measurements showed the average midline thorax dose to be 82.4 percent of the midline air dose. In accordance with the suggestion of Bond and co-workers (*6*) the doses reported are all in terms of midline tissue dose (MTD).

Irradiation Procedures

To avoid possible modification of the response by anesthesia or other medication a plywood retaining box was used for restraint. The xiphoid process of the experimental animal was palpated and the box marked accordingly. Both animal and box were then placed within the shielding to this level with the animal fixed in place by means of straps (fig. 2). The portion exposed included the tissues cephalad of the diaphragm, a small portion of the stomach and liver, and the very tip of the spleen.

Since bilateral irradiation with 250–2,000 kvp. X-rays has been reported to yield essentially uniform tissue-dose distribution (*6*), this method of irradiation was used throughout the study. Similar techniques were used for the whole body irradiation experiment except that there was no shielding. Each exposure was carried out with the midline of the animal 1 meter from the X-ray target. The X-ray beam was centered on the midpoint of the exposed area.

Five groups of 10 animals were exposed to upper body irradiation at dose levels of 800, 1,000, 1,500, 1,750, and 2,000 r. A sixth group of 10 dogs was sham irradiated under conditions identical to those for the 1,500 r group. Three groups of four dogs each were given whole body irradiation at the 800, 1,000, and 1,500 r levels, and single animals were exposed at the 1,750 and 2,000 r levels. Three groups of seven dogs each were exposed to whole body irradiation of 215, 230, and 280 r.

In order to reduce the incidence of postirradiation vomiting, the animals were fasted on the exposure day. They were examined daily for 30 days after irradiation. Examinations included clinical observations, neurological examinations, and recording of weights and rectal temperatures. All survivors are maintained under constant surveillance for a delayed effect study.

Results

The 30-day mortality for whole body irradiation is shown in table 1, and for upper body irradiation, in table 2.

The dose mortality curves constructed by the method of Litchfield and Wilcoxon (*7*) are shown in figure 3. A correction factor of 89.7 percent was used to represent the 100 percent mortality found at the 2,000 r level. The LD–50/30 for whole body irradiation is 250 r with 95 percent confidence limits of 225–278 r. This is in agreement with results reported by Bond and co-workers (*8*) for mongrel dogs. Gleiser (*9*) reports an LD–50/30, in air, of 316 r for Walker foxhounds. When corrected by the previously cited cadaver depth-dose measurement of 82.4 percent, this corresponds to 260 r MTD. These results are lower than the 335 r MTD reported by Shively and co-workers (*10*) for cobalt-60 irradiation of mongrel dogs.

The LD–50/30 for upper body irradiation is 1,775 r with 95 percent confidence limits of 1,504–2,095 r.

Table 1. Thirty-day mortality resulting from whole body exposure of beagles to 1,000 kvp. X-rays

Dose (roentgens)	Mortality [1]	Mean day of death	Range in day of death
215	1/7	26	----------
230	3/7	17. 7	15–20
280	5/7	13. 6	10–16
800	4/4	8. 25	8– 9
1,000	4/4	4	4
1,500	4/4	4	4
1,750	1/1	4	----------
2,000	1/1	4	----------

[1] Number dying/number irradiated.

Figure 2. Animal in place ready for exposure

Table 2. Thirty-day mortality resulting from upper body exposure of beagles to 1,000 kvp. X-rays

Dose (roentgens)	Mortality[1]	Mean day of death	Range in day of death
Sham	0/10		
800	0/10		
1,000	0/10		
1,500	1/10	12	
1,750	3/10	14	13–15
2,000	10/10	10. 1	4–13

[1] Number dying/number irradiated.

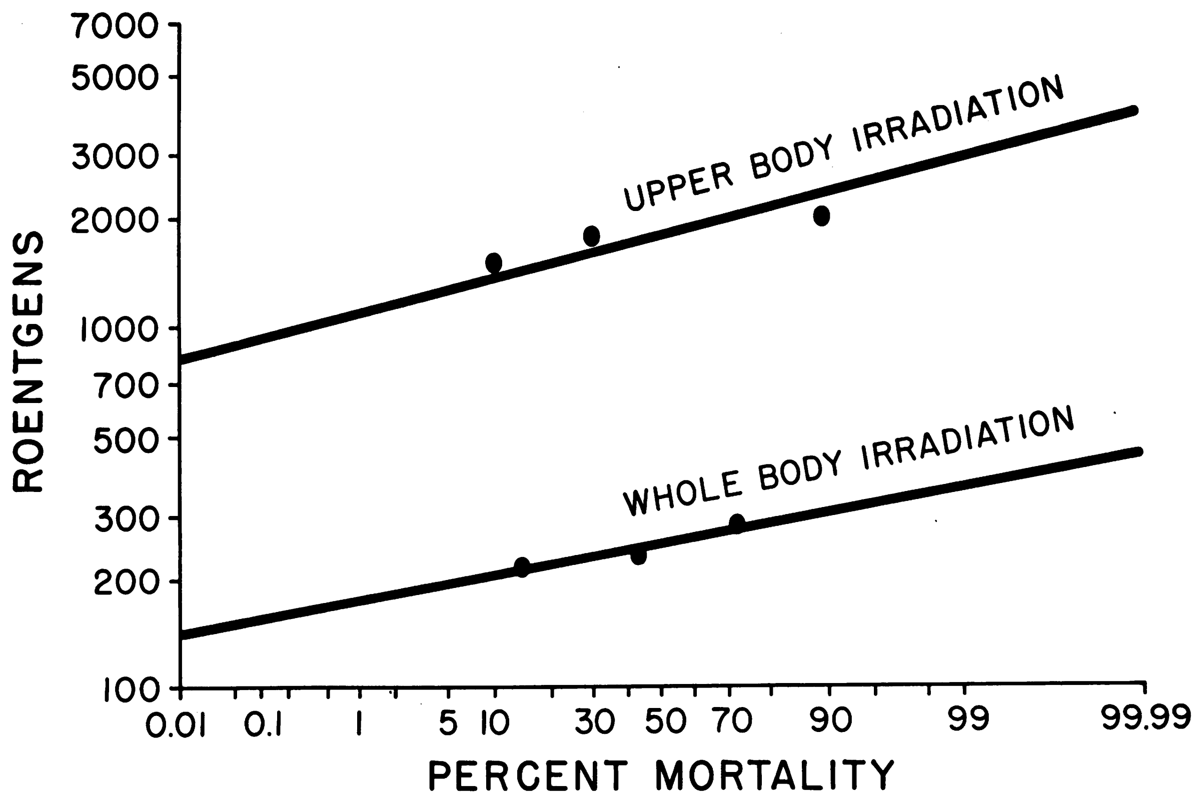
Discussion

Lethality in the beagle is significantly modified by shielding the lower portion of the body. The LD–50/30 for upper body irradiation is approximately seven times that for whole body irradiation. The figure for upper body irradiation for the dog is very close to that for the rat (*3*). The modification in lethality observed in shielding the lower portion of the body, however, is greater for the dog (250 to 1,775 r) than for the rat (750 to 1,750 r). This may be explained in part by the volume of tissue shielded or by a difference in critical organ shielding.

Blair (*11*) has stated that "the gram roentgen dose for lethality will tend to be the same for the whole body inhomogenously exposed, homogenously exposed, and partially exposed." He further states that this rule may fail in either direction depending upon the radiosensitivity of the exposed tissue. In this study the gram-roentgen dose required to produce a median lethal dose is raised fourfold by the shielding of the lower portion of the body.

Several authors (*2,4,12,13*) suggest that the protection afforded by shielding part of the body results from either a sparing action exerted by the protected tissue on the exposed injured tissues or production of humoral factors by the protected tissue which could influence recovery. Our study, as a whole, suggests a stimulation of certain recovery processes which may arise from the shielded tissue.

Figure 3. Dose mortality curves



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Summary

In experiments with beagles, the LD–50/30 for animals with whole body exposure to 1,000 kvp. X-rays is placed at 250 r. The LD–50/30 for upper body exposure to 1,000 kvp. X-rays is placed at 1,775 r. The gram-roentgen dose required to produce a median lethal dose is raised fourfold by the shielding of the lower portion of the body.

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City Health Officers Organize

The establishment of the United States Conference of City Health Officers by the health officers of the Nation's cities was announced in January 1961. The purposes of the organization are:

• To promote, in all its branches, improved municipal public health administration throughout the United States.

• To interchange ideas and experiences and to obtain expert advice on the many and varied special health administrative problems of the major municipalities of the country.

• To foster proper and adequate relationships on mutual health problems between the Federal Government and the States and cities.

• To support the development and maintenance of adequate communications and working relationships between the city health departments, the Association of State and Territorial Health Officers, and the Public Health Service.

• To promote municipal cooperation in order to assist in the improvement of local public health administration.

Harry R. Betters is executive director of the organization; Dr. Huntington Williams, commissioner of health, Baltimore, is president; and Dr. Leona Baumgartner, commissioner of health, New York City, was named vice president. Trustees are Dr. George A. Denison, health officer, Birmingham; Dr. E. R. Krumbiegel, commissioner of health, Milwaukee; Dr. Sanford Lehman, director of public health, Seattle; Dr. Joseph G. Molner, commissioner of health, Detroit; and Dr. George M. Uhl, city health officer, Los Angeles.