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VETERINARIAN

THE EARLY EFFECT OF IONIZING RADIATION ON LARGE ANIMALS[1,2]

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INTRODUCTION

The University of Tennessee-Atomic Energy Commission (U.T.-A.E.C.) Agricultural Research Laboratory is a unit of the University of Tennessee Agricultural Experiment Station. The Laboratory originated in 1948 as a result of an agreement between the University of Tennessee and the U.S. Atomic Energy Commission in which the University agreed to maintain and study a group of Hereford cattle that was accidently exposed to radioactive fallout from the first atomic bomb test in July 1945. The Laboratory facilities are owned by the Atomic Energy Commission and the research is performed by the University of Tennessee under contract with the A.E.C.

I would like to discuss one area of research at our Laboratory which deals with the early effects of external irradiation on large animals.

One may classify effects of irradiation upon animals by both source of radiation and onset of effects. The source may be external or internal and the effects may appear early or late in relation to exposure. An external source is any radioactive material outside the body (may be on the skin) which subjects the animal to ionizing radiation, and an internal source is any radioactive material within the body.

Early or acute effects generally encompass those effects observed within 30 days after irradiation and late effects are changes which are manifested several months to years later.

MORTALITY

The median lethal air dose expressed in roentgens (r) for 50 per cent of the animals in 30 days (LD 50/30) is listed by species in Table 1.[1,2,3,4,5,6]

Mortality is influenced by dose rate, source of radiation, type of radiation, and species of animal. The variation in response to various sources of radiation is demonstrated by the LD 50/30 for burros exposed to Co^{60}, Ta^{182} and $Zr\text{-}Nb^{95}$ (Table 1). These differences in response to gamma radiation from the different isotopes may be attributed in part to the different energies of the rays. The energies of gamma rays of Co^{60}, Ta^{182}, and $Zr\text{-}Nb^{95}$ decrease in that order. Thus it appears that rays of lower energies are more effective from the standpoint of acute

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Table 1 – Median Lethal Doses

Species	Source of Irradiation	$LD_{50/30}$ Air Dose
Bovine:		
Adults (Herefords)	CO^{60}	543 r
Yearlings, 15–20 Mos. (Herefords	Co^{60}	Approx. 450 r
Porcine – 6 Mos. 200–250 lbs.	Co^{60}	618 r
Ovine- Adults	$Zr\text{-}Nb^{95}$	525 r
Equine (Burros)	Co^{60}	784 r
	Ta^{182}	651 r
	$Zr\text{-}Nb^{95}$	580 r
	Bomb	375 rads
Poultry	Co^{60}	900

mortality when the $LD_{50/30}$ is expressed as dose in air.

The higher mortality response with bomb irradiation may be attributed to either the type of radiation, neutron and gamma, or to dose rate which was instantaneous. It was our assumption that perhaps both factors contributed to the higher mortality. Later experiments have tended to confirm this assumption.

Survival times and modes of death as well as the incidence of early mortality may be influenced by dose rate. A comparison of survival times for those animals which died within 30 days is listed in Table 2. Animals which survive 30 days usually recover from acute effects, but may die several months to years later from delayed effects.

SYMPTOMATOLOGY

Symptoms most commonly observed indicate damage primarily to four systems of the body: the nervous

Table 2 – Survival Time

Species	Exposure	Source	Dpse rate	Dose range (r)	Mean survival (days)
Bovine	Total body	Co^{60}	55 r/hr.	450–700	10.3
Porcine	Total body	Co^{60}	50 r/hr.	450–890.	14.4
Ovine	Total body	$Zr\text{-}Nb^{95}$	18 r/hr.	450–650	18.9
Equus (burro)	Total body	Co^{60}	50 r/hr.	600–945	14.7
	Total body	Ta^{182}	20 r/hr.	640–820	25.8
	Total body	$Zr\text{-}Nb^{95}$	16 r/hr.	500–900	22.3
	Total body	Bomb	Instantaneous	300–800	5.0
	Head	Co^{60}	100 r/min.	250–1200	2.0

system, the digestive system, the blood system, and the respiratory system.

Symptoms of encephalitis are frequently observed in burros exposed to relatively high dose rates. This syndrome is similar to that observed in equine encephalomyelitis. It is associated with early death--generally withing five days after exposure. Encephalitis has not been observed in other large animals except those exposed to supralethal doses (2000 r and above).

Although encephalitis has not been observed in cattle, sheep, or swine exposed to single doses of 1000 r or less, other signs are manifested which suggest functional disturbance of the nervous system. These included muscle tremors, spastic muscles, knuckling of fetlock joints of hind legs, and tenesmus.

Digestive disturbances are generally manifested by depressed appetite, diarrhea, and weight loss. Diarrhea begins in cattle and sheep during the second week after irradiation and frequently progresses to a thin hemorrhagic state before death.

Loss of weight is not pronounced in cattle and sheep primarily because their appetite is not severely depressed until two to three days before death. Burros and swine lose more weight because feed consumption is reduced soon after exposure to lethal doses.

Damage to the blood system is manifested by a hemorrhagic syndrome and a decrease in cellular elements of the peripheral blood. The hemorrhagic syndrome usually begins during the latter part of the second postirradiation (PI) week and is characterized by spontaneous hemorrhage from scars and old wounds, subcutaneous hematomas and hemorrhage. Hemorrhage is frequently observed in nasal discharge, from the mouth, and in excreta.

Changes in blood cell values are similar in all four species of large animals we have studied. As an illustration of these changes, I will use those changes we have observed in cattle[7].

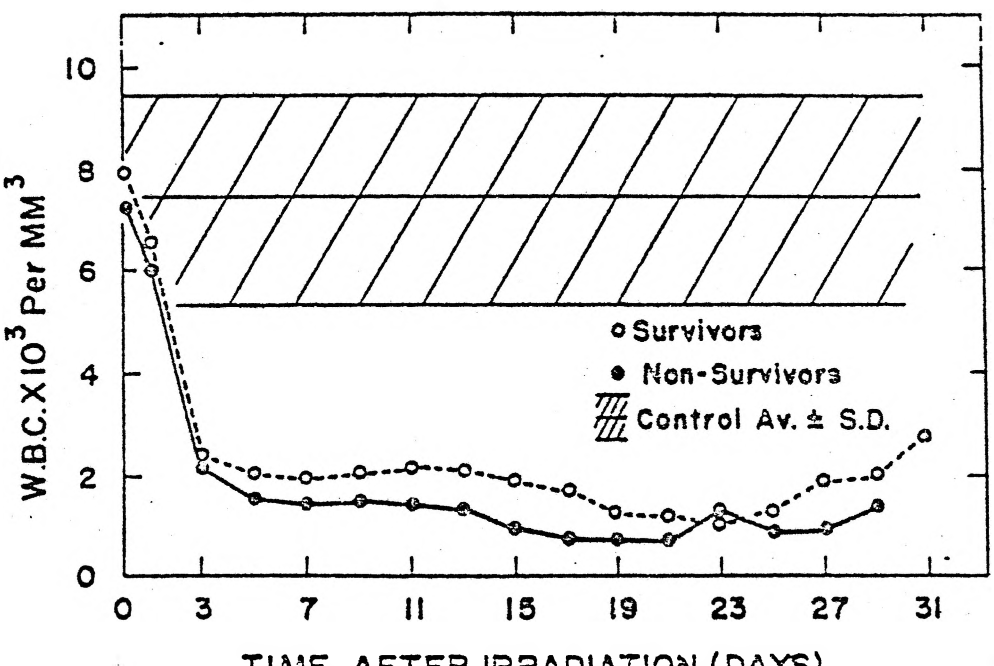

Figure 1. The mean leukocyte counts of cattle following exposure to 450 to 700 r of Co^{60} gamma radiation.

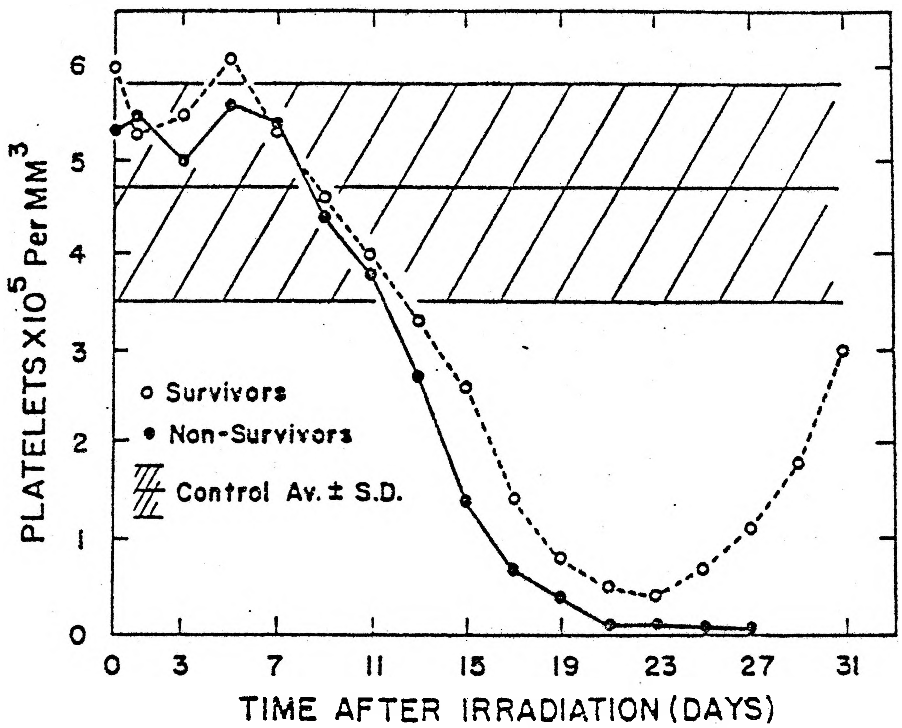

Figure 2. Postirradiation platelet counts of cattle exposed to 450 to 700 r of Co^{60} gamma radiation.

The total white blood cell counts (WBC) (Fig. 1) dropped 70% during the first three PI days. The lowest values occurred between PI days 15 and 25. Total granulocytes, primarily neutrophils, increased during PI day one, but this was not reflected in the total WBC because of the early and rapid decline in lymphocytes. Lymphocyte counts increased slightly after maximum depression on PI day three and remained nearly constant through PI day 25. In contrast, granulocyte counts continued to decrease with maximum depression between PI days 15 and 25. This was the period during which most of the deaths occurred.

The platelet counts (Fig. 2) began to decrease about PI day 7 and declined at a rate of approximately 45,000/mm^3/day, reaching the lowest levels near PI day 21. The rate of decrease was the same in survivors and nonsurvivors. However, the counts of the survivors did not drop below an average of 40,000/mm^3, whereas the counts of the nonsurvivors dropped to near zero.

Erythrocyte counts decreased in all irradiated cattle but was most pronounced in those which died (Fig. 3). The hemoglobin and packed cell volume values had a similar pattern to that of the red blood cells. Consistently lower values were recorded in the nonsurvivors.

Respiratory distress is commonly observed in the four species of large animals we have studied. In cattle receiving lethal doses, it is first observed at end of the second PI week. Onset of the condition is characterized by rapid, shallow respirations, occasionally with raspy sounds and accompanied by thick, stringy, clear or light yellow nasal discharge. In some cases, this condition progresses rapidly to forced respirations with sounds audible several yards away and is accompanied by coughing. The nasal discharge frequently is red from hemorrhage occurring in the membranes of the frontal and maxillary sinuses. In sheep, severe hemorrhage often occurs in lateral masses of the ethmoid bone and the nasal cavity

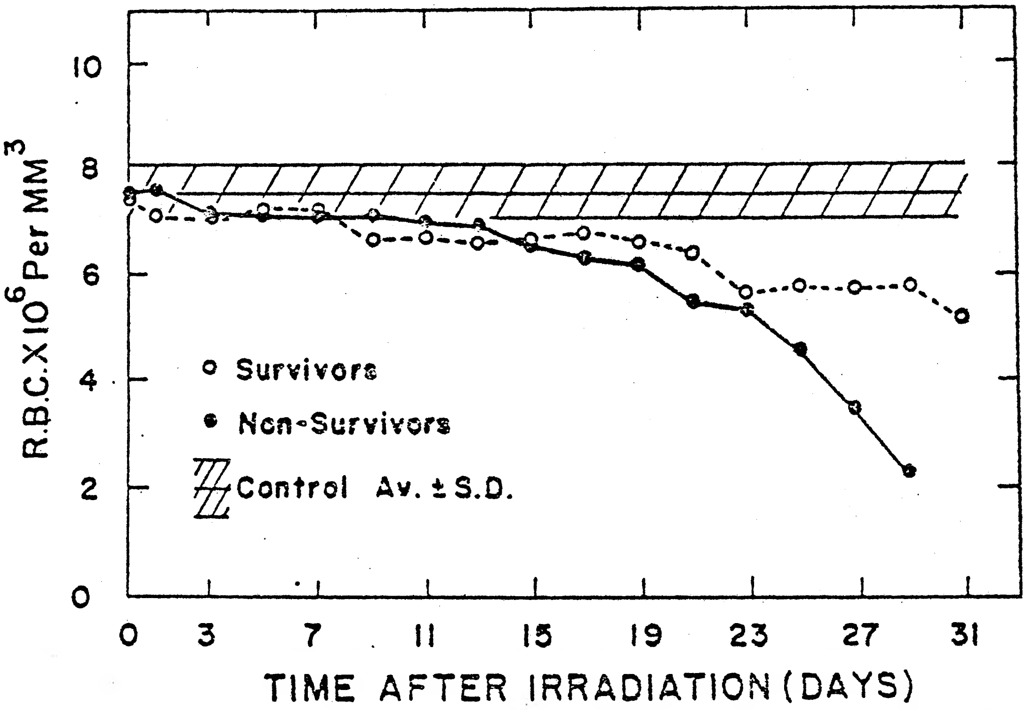

Figure 3. Erythrocyte counts of cattle following exposure to 450 to 700 r of Co^{60} gamma radiation.

frequently becomes plugged with clotted blood. Respiratory distress is generally attributed to edema of larynx and lungs.

Changes in rectal temperatures are consistent in cattle and sheep. Temperature changes in cattle are illustrated in Fig. 4. At the end of the irradiation period, rectal temperature of 80% of irradiated cattle was one to three degrees above normal. Within 24 to 48 hours, all temperatures had returned to normal and remained so until approximately PI day 14. After PI day 14, temperatures began to rise rapidly and all decedents were febrile for three days or more prior to death. Temperatures of 108 to 110° F. were recorded in several cattle which died. The average survival time of the decedents was five days after onset of fever.

The rectal temperature of cattle which have been exposed to irradiation appears to be the factor which is most reliable for selecting animals suitable for food. If the temperatures are normal and the cattle are alert and physically strong, they will be acceptable for slaughter under emergency conditions.

GROSS PATHOLOGY

The macroscopic lesions are related more closely to survival time than to dose. Animals which die early (one to five days after irradiation) have edema of lungs, petechia in area of coronary vessels, congestion and submeningeal hemorrhage of the brain, and occasional ecchymotic hemorrhage in the intestinal wall. Those surviving 10 to 25 days have generalized hemorrhage throughout the body. The hemorrhage is generally more diffuse in the abdominal and thoracic viscera than in other tissues. Lesions of infections, such as pneumonia, are more common during this period. Necrotic ulcers are quite common in the large intestine, particularly in swine which survive 15 to 25 days.

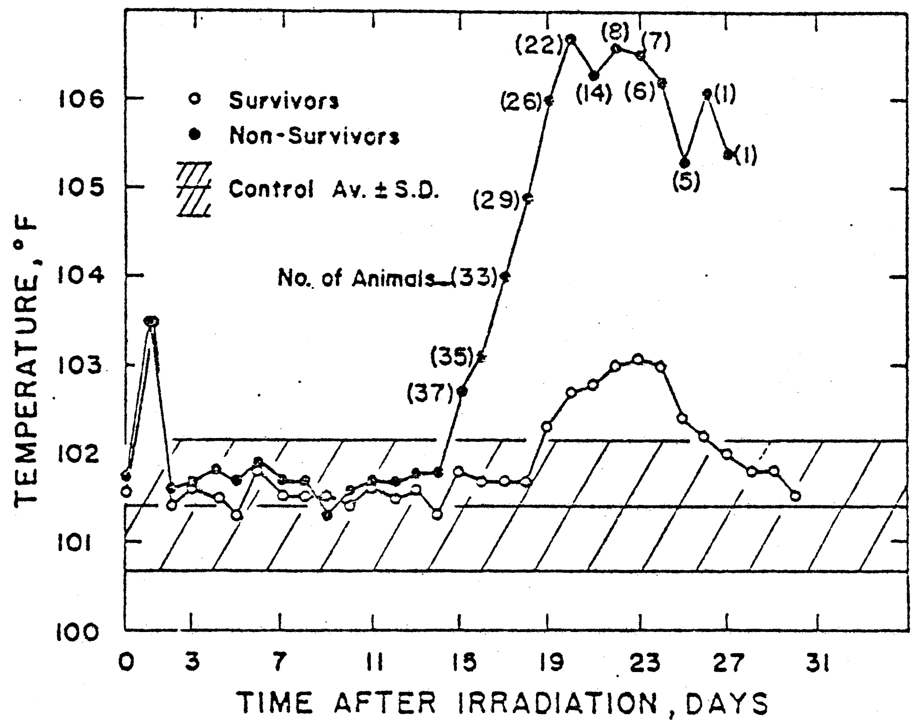

Figure 4. Rectal temperatures of cattle following exposure to Co^{60} gamma radiation. Dose range 450 to 700 r.

DIAGNOSIS

There are no clinical signs or pathologic changes which are specific for irradiation sickness; therefore, a practitioner would find himself in a difficult situation if a need for diagnosis of irradiation sickness arose without an accurate knowledge of the irradiation history. There are many hemorrhagic diseases and conditions which resemble irradiation damage and one must be prepared to make a differential diagnosis from diseases such as blackleg, anthrax, hog cholera, and erysipelas, and from toxic agents such as bracken fern, dicoumarin and trichloroethylene. A careful evaluation of the clinical history, the blood picture, and the gross pathology are necessary to make a diagnosis of irradiation sickness. Of course, if the irradiation dose is known, then diagnosis can be made with a much higher degree of confidence.

THERAPY

Our experience with therapy of irradiation sickness in large animals has been limited; therefore, the following statements are made with reservations. Therapy must be directed towards control of hemorrhage, infection, and loss of body fluids from diarrhea. Fresh whole blood transfusions are indicated for the primary purpose of replacing platelets. This procedure is quite expensive and time consuming and our results have been disappointing. The use of systemic hemostats has also failed to produce satisfactory results. Antibiotics in large doses will control infections and electrolytes given parenterally will maintain body fluids, but unless the hemorrhagic syndrome is controlled these are of little benefit.

I am of the opinion that therapy is of little, if any, benefit if done early on a group or herd basis. However, it appears that therapy on a selective basis would be profitable. As I stated earlier, animals which survive 30 days usually recover. Those animals which are in fair to good condition 20 days after irradiation will probably survive the hemorrhagic syndrome if infection and dehydration are controlled. These are the animals which can be treated with a fair degree of success using large doses of penicillin and streptomycin or broad-spectrum antibiotics at onset of fever and parenteral electrolytes with dextrose to control dehydration. Calcium therapy appears to be of benefit when animals develop stiff gait.

SUMMARY

The $LD_{50/30}$ for cattle, sheep, swine, and burros exposed to external gamma radiation varies from 525 to 780 r. The clinical syndrome varies somewhat with the species. The most consistent change observed in all large animal studies was a reduction in cellular elements of the peripheral blood. The symptoms commonly observed were hemorrhage, diarrhea, nasal discharge, lacrimation, anorexia, posterior weakness, and dyspnea. Hemorrhage from the nose, mouth, anus, and in excreta was a common finding during the second and third weeks after irradiation. The most common gross lesion observed in animals which die from irradiation is hemorrhage. There are no lesions or symptoms which are pathognomonic for irradiation damage.

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NEW SAUNDERS OBEDIENCE FILM TO BE AVAILABLE FROM GAINES

Blanche Saunders' new film on novice obedience training will be distributed exclusively through the Gaines Dog Research Center, it was announced by Harry Miller, director.

The 16 mm film, in color and sound and running about 30 minutes in length, will replace the earlier "Training You to Train Your Dog" (Basic) motion picture which the Center has been distributing for about 15 years. The new film won the Dog Writers Association of America award for the best dog film made during 1963.

Reservations for group showings after May 1 are now being accepted. Correspondence pertaining to the film should be directed to the Gaines Dog Research Center, 250 Park Avenue, New York, N. Y. 10017. There is no rental charge for the film, but the group requesting a showing agrees to pay the two-way shipping charges for the print and also to take good care of the print while in its possession.

Miss Saunders has been the No. 1 obedience personality through the 30 years of the movement's existence in the United States. The camera work on the film was done by J. Kilburn King, dog man who is also well-known for the films he has produced for various dog groups in recent years.