SUMMARY PAGE

THE PROBLEM

Studies of the tolerance of mice to either the stress of whole body X-irradiation or the stress of explosive decompression per se initiated a further study to determine the tolerance of mice to a stress condition compounded of a medial lethal dose of X-irradiation followed by an exposure to explosive decompression of a magnitude sufficient to produce a medial lethal dose in nonirradiated animals.

In addition, the evaluations of exposure of animals to an oxygen rich environment during exposure to whole body X-irradiation were conducted.

FINDINGS

On the basis of pooled survival data it is concluded that the use of either an air or oxygen rich environment during exposure to 700r whole body X-irradiation has no effect on the tolerance of mice to explosive decompression when the stress of decompression is applied within one hour following X-irradiation. The expected thirty-day survival proportion of mice exposed to whole body X-irradiation only while breathing oxygen is significantly reduced when compared to the survival proportion of mice breathing air.

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INTRODUCTION

Effective evaluation of the stress of X-irradiation in combination with the stress of explosive decompression requires a basic understanding of the effect of either stress applied singularly. Evidence of tolerance to either stress condition can be expressed in terms of mortality occuring in the population being tested. The establishment of a medial lethal dose expressed as the L. D. 50 for animals being X-irradiated has become an accepted criterion for tolerance to the stress of whole body irradiation (1). Recently, the establishment of an L. D. 50 dose for animals undergoing the stress of explosive decompression per se has been reported (2). Since the L. D. 50 is of particular value as a measure of biological response, it can be used to compare various lethal stress conditions. The animal radiosensitivities are more accurately expressed in terms of a projected survival; that is, if the X-irradiation dose proves fatal to 50 per cent of the test population in thirty days, it is expressed as the L. D. 50/30 (1).

Studies of the tolerance of mice to either the stress of whole body X-irradiation (3) or the stress of explosive decompression per se (2) initiated a further study to determine the tolerance of mice to a stress condition compounded of a medial lethal dose of X-irradiation followed by an exposure to explosive decompression of a magnitude sufficient to produce a medial lethal dose in nonirradiated animals. Consideration of the problems related to interpretation of the various events occurring as a result of explosive decompression per se with relationship to survival of small animals has been previously reviewed (2).

During an investigation (3) designed to study the effects of X-irradiation in conjunction with the stress of explosive decompression consideration was given to the possible variation in radiosensitivity of experimental animals exposed to an oxygen rich environment. Experimental findings have indicated that reduction of the environmental oxygen tension at the time of X-irradiation not only decreases the over-all radiation effect on the intact animal but also reduces mortality (4). Experiments to determine the degree of radiosensitivity of biological systems X-irradiated in high oxygen concentrated environments indicate an increased radiosensitivity as compared to X-irradiation of the systems in an air environment (5,6).

This report is an attempt to correlate mortality resulting from two distinct stress conditions when applied either separately or in combination. The effect on the intact animal of an oxygen rich environment during X-irradiation is also reported.

APPARATUS AND PROCEDURE

Male Swiss albino laboratory mice (20-35 gms) in the tenth to twelfth week of age were used in these studies. The mice were housed in the animal quarters until the day of treatment and maintained on standard laboratory food; no restrictions were placed on food or water consumption prior to and following the experiment.

A total of 220 mice were selected for exposure to X-irradiation. Thirty minutes prior to exposure to the radiation source ten mice were selected at random from the colony and installed in plastic containers. These containers were fabricated from 1/8-inch thick plexiglas, measuring 6 inches in over-all diameter and 3 inches in depth. The interior was divided into three compartments by two 1/8-inch circular perforated plexiglas plates. A hole 1/4 inch in diameter was opened in the top and bottom center surface of the container for exhaust gas flow. Air or oxygen entered the middle compartment via a 1/8-inch diameter bore plastic stem attached to the side of the container. A circular entrance port 3/4 inch in diameter was cut in the side of the upper and lower compartment for installation and egress of the animals.

Five mice, in each group of ten, were placed in the upper section and five mice in the lower section of the plastic container. The entrance ports were then sealed by insertion of a number 5 solid rubber stopper. The respiratory gas source was immediately activated and the flow rate adjusted to allow for a continuous ventilation (1.9 LPM) of the container with either air or oxygen.

Gas supplied to the plexiglas animal container was from a 514-cubic inch high pressure cylinder, containing either water pumped compressed air or 100 per cent aviator's breathing oxygen. The cylinder was connected to an A-14 oxygen regulator with the selector switch placed in the 100 per cent position to eliminate the dilutor feature. A single hole, rubber stopper with a stainless steel center tube was fitted to the outlet of the A-14 regulator and gas was carried from this fitting through a 1/8-inch interior diameter rubber tube to the inlet port of a Fischer Laboratory Flow Meter. The flow meter outlet was connected to the 1/8-inch bore plastic stem of the animal container by a piece of rubber tubing.

The radiation source was a Picker X-Ray Therapy Unit having half-wave rectification and 1/2 mm Cu and 1 mm Al filters. MA peak voltage was read at 180 KVP at 15 milliamps and the focus mid-point distance was measured at 33.4 cm. The radiation source was adjusted to deliver at the rate of 50r per minute to effect a total whole body dose of 700r during the fourteen-minute exposure period. Field strength calibrations were made using a Victoreen Model 70 condenser r meter with a 250r chamber. Dosage did not vary more than 5 per cent from the initial calibration.

The plastic animal container was then placed in the radiation field so that animals would be irradiated from the dorsal to ventral aspect and the X-Ray Therapy unit was activated. At the completion of the exposure period the container was removed from the field and the respiratory gas cylinder valve was secured in the closed position.

Five of the animals in the plastic containers were then placed in a small metal cage and returned to the animal quarters for a thirty-day observation period. The remaining five animals in each group were placed in special wire mesh cages and transported to the animal decompression chamber.

Twelve separate decompressions were performed from sea level to a terminal altitude of 30,000 feet. Fifteen animals were subjected to decompression simultaneously: five which had been X-irradiated while breathing air, five X-irradiated while breathing 100 per cent oxygen, and five others that had not been irradiated. The decompressions were accomplished by perforating acrylic diaphragms separating an animal chamber from a large vacuum chamber (2). The pressure change occured in approximately 0.01 second. Recompression was begun immediately and the total recompression time was less than twenty seconds. All decompressions took place within one hour following exposure to whole body X-irradiation. Those animals which died within one hour following explosive decompression were counted as fatalities from the effects of decompression.

Thirty mice not selected for exposure to X-irradiation or explosive decompression were marked as C-1 and maintained in the animal quarters in the same type of cage used for the treated animals and feed according to the same dietary schedule. The purpose of maintaining this group of animals was to insure that the environmental and dietary conditions of the animals being studied for post-irradiation survival did not adversely influence the mortality rate. During the same time period twenty additional mice (marked as C-2) from the colony were placed in the plastic animal containers, ventilated in either an air or a 100 per cent oxygen environment using the same type of respiratory gas apparatus as used with the irradiated animals. These animals were kept in a room adjacent to the area containing the radiation source and at the completion of the experimental procedure were transported to the animal quarters and maintained under the same conditions as described for the animals in the C-1 group.

RESULTS AND DISCUSSION

Evaluation of the pooled data presented in Table I indicates there is no significant difference in tolerance to explosive decompression regardless of the gaseous environment when animals receive an L. D. 50/30 day dose of whole body X-irradiation. Furthermore there is no significant difference, expressed as proportion survival, between irradiated and nonirradiated animals explosively decompressed to a terminal altitude which had previously been determined (2) to effect a 50 per cent mortality under the same physical conditions of explosive decompression utilized in this experiment. The data in Table I indicate that the stress of X-irradiation at a level effective enough to produce an L. D. 50/30 day mortality did not compound the effect produced by the stress of explosive decompression per se even though the stress level is severe enough to effect a 50 per cent mortality in the nonirradiated, explosively decompressed animals.

The dose strength of 700r whole body X-irradiation effected a 46 per cent survival (Table II) at the completion of the thirty-day observation period for animals breathing air during exposure to X-irradiation. In contrast, only three animals, or 6 per cent, of the mice exposed to 700r whole body X-irradiation while breathing 100 per cent oxygen were alive at the end of the thirty-day period. This fact may lend support to the concept

Table I

Mortality in Mice Undergoing Explosive Decompression

Type of Treatment	Number of Animals	Number Survivors	Proportion Survival
X-irradiated in Air	60	29	0.483
X-irradiated in Oxygen	60	31	0.516
Nonirradiated	60	30	0.500
Total Decompressed	180	90	0.500

Table II

Five-Day Interval Proportion of Survivors From 700r Whole Body X-Irradiation in Air or Oxygen

	Air		Oxygen	
Day	Total Number of Animals	Proportion Survival	Total Number of Animals	Proportion Survival
0	50	1.000	50	1.000
5	45	0.900	45	0.900
10	38	0.760	31	0.620
15	31	0.620	10	0.200
20	25	0.500	6	0.120
25	23	0.460	4	0.080
30	23	0.460	3	0.060

that increased oxygen pressures tend to enhance the severity of effects produced by whole body X-irradiation. While the figures in Table II tend to indicate a significant difference in survival between animals X-irradiated in an oxygen rich environment as compared with an air environment, it should be noted that the data represent only fifty animals in each category. It should be noted also (Table II) that the greatest mortality occured between the tenth and fifteenth day in the animal population X-irradiated in the oxygen rich environment.

The purpose of Table III is to show the thirty-day survival proportions of all mice utilized in this study. The value for the nonirradiated, explosively decompressed animals when recorded one hour post decompression indicates that 50 per cent of this group survived explosive decompression. The values for the animals in the X-irradiated, decompressed category have been adjusted from Table I to indicate a survival proportion of 1.000 based on the total number of animals remaining one hour post exposure to explosive decompression.

It should be noted (Table III) that, of the X-irradiated, decompressed animals, 10.3 per cent of the animals breathing air and 6.4 per cent of those animals breathing oxygen, at the time of X-irradiation, had survived the compounded stress at the end of the thirty-day observation period.

While the data presented in this study indicate that the effects of whole body X-irradiation do not significantly alter the tolerance of mice to explosive decompression when the two stress conditions are applied to mice over a relatively short time, a more detailed study is in progress to correlate the development of pulmonary damage induced by X-irradiation with tolerance to explosive decompression.

Table III

Thirty-Day Survival Proportion of All Mice

	X-IRRADIATED				NONIRRADIATED	
	AIR		OXYGEN			
Day	Decompressed	Non Decompressed	Decompressed	Non Decompressed	Decompressed	Non Decompressed
0	1.000*	1.000	1.000*	1.000	0.500#	1.000
5	0.827	0.900	0.935	0.900	0.500	1.000
10	0.656	0.760	0.354	0.620	0.500	1.000
15	0.275	0.620	0.064	0.200	0.500	1.000
20	0.172	0.500	0.064	0.120	0.500	1.000
25	0.103	0.460	0.064	0.080	0.500	1.000
30	0.103	0.460	0.064	0.060	0.500	1.000

*Expressed as total population remaining one hour post explosive decompression

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Male Swiss albino mice exposed to 700r whole body X-irradiation while breathing either air or 100 per cent oxygen were explosively decompressed from sea level to a terminal altitude of 30,000 feet. A second group of mice exposed to X-irradiation only while in an air or oxygen rich environment were maintained for a 30-day observation period.

On the basis of pooled survival data it is concluded that the use of either an air or oxygen rich environment during exposure to X-irradiation has no effect on the tolerance of mice to explosive decompression as evidenced by immediate survival or 30-day survival. The expected 30-day survival proportion of mice exposed to whole body X-irradiation only while breathing oxygen is significantly reduced when compared to the survival proportion of mice breathing air.

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