AD 699 129

# PERFORMANCE OF MINIATURE PIGS AFTER PARTIAL BODY IRRADIATION

J. W. Thorp, et al

Armed Forces Radiobiology Research Institute
Bethesda, Maryland

December 1969

AD 699129

AFRRI SR69-20
December 1969

# PERFORMANCE OF MINIATURE PIGS AFTER PARTIAL BODY IRRADIATION

J. W. THORP
R. L. CHAPUT
R. T. KOVACIC

R. E. George
R. E. GEORGE
Commander, MSC, USN
Chairman
Radiation Biology Department

Hugh B. Mitchell
HUGH B. MITCHELL
Colonel, USAF, MC
Director

ARMED FORCES RADIOBIOLOGY RESEARCH INSTITUTE
Defense Atomic Support Agency
Bethesda, Maryland

---

ACKNOWLEDGMENT

The authors wish to thank W. F. Pfeiffer for accomplishing the extensive dosimetry. E. L. Barron and the members of his staff T. K. Dalton, N. L. Fleming, M. E. Flynn, J. K. Warrenfeltz and W. W. Wolfe gave invaluable help in training, exposing, and testing the experimental subjects.

TABLE OF CONTENTS

## LIST OF FIGURES



## LIST OF TABLES

## FOREWORD
(Nontechnical summary)

Incapacitation has been observed in monkeys, dogs, and miniature pigs that received supralethal, pulsed doses of ionizing radiation. Over a fairly wide range of such doses, the pig and the monkey experienced a period of early transient incapacitation (ETI) from which they recovered to perform satisfactorily for several hours. ETI was not observed in the dog; after the onset of incapacitation, the dog's condition declined continually without improvement.

Either head shielding or trunk shielding alleviated or prevented the symptoms of ETI for the monkey. Head shielding prevented early onset of incapacitation in the dog, but trunk shielding did not. The purpose of this study was to determine whether head or trunk shielding would alleviate or prevent early incapacitation in irradiated miniature pigs.

Thirty-two miniature pigs (males, females, and barrows) were trained by shock avoidance conditioning to traverse a two-chambered shuttlebox. Eight unshielded pigs (whole-body exposed) received midline tissue doses (MTD) of about 13,000 rads of pulsed, mixed gamma-neutron radiations to the head and trunk. Eight head-shielded and eight trunk-shielded pigs received doses to the unshielded part of the body that were equivalent to the doses received by unshielded animals. Four trunk-shielded pigs received 6[illegible] rads to the head, and four others received 3000 rads to the head. The MTD behind the shield (at the middle of the head or trunk) was less than 7 percent of the MTD to the same point without the shield in place. Postirradiation performance was evaluated.

In the 13,000-rad dose groups, ETI or immediate, permanent complete incapacitation (PCI) occurred in all of the unshielded pigs and in seven of the eight trunk-shielded pigs. The other trunk-shielded pig did not suffer ETI, but its early post-irradiation performance was far below preirradiation levels. One head-shielded pig suffered ETI, which appeared to be due to paralysis of the hind legs. Three head-shielded subjects seemed slightly ataxic for 5 to 10 minutes after irradiation, but they continued to perform at acceptable levels by avoiding shock at least 90 percent of the time. ETI also occurred in the four trunk-shielded pigs that received 6000 rads to the head and in one of the four that received 3000 rads.

In the 13,000-rad dose groups, two unshielded pigs and one trunk-shielded pig suffered immediate PCI. Survival times of 4 hours or less were observed in both groups. Early deaths (within 4 hours) did not occur among the head-shielded pigs nor among the trunk-shielded pigs that received lower doses. However, all trunk-shielded animals that escaped the early death had longer survival times than comparable head-shielded or unshielded animals.

It appears, therefore, that radiation damage within the head is the primary cause of early death, ETI, and early PCI in irradiated pigs, and head shielding would help prevent these phenomena. However, trunk shielding would be expected to extend the survival and effectiveness of irradiated pigs if early death does not occur.

## ABSTRACT

Thirty-two miniature pigs were trained by shock avoidance conditioning to traverse a two-chambered shuttlebox. Eight unshielded pigs (whole-body exposed) received midline tissue doses (MTD) of about 13,000 rads of pulsed, mixed gamma-neutron radiations to the head and trunk. Eight head-shielded and eight trunk-shielded pigs received doses to the unshielded part of the body that were equivalent to the doses received by unshielded animals. Four trunk-shielded pigs received 6000 rads to the head, and four others received 3000 rads to the head. MTD behind the shield (at the middle of the head or trunk) was less than 7 percent of the MTD to the same point without a shield in place. Postirradiation performance was evaluated. All unshielded pigs suffered early transient incapacitation (ETI) or immediate, permanent complete incapacitation (PCI); several early deaths (within 4 hours) occurred among these animals. Head shielding prevented ETI, immediate PCI, and early deaths, but trunk shielding did not. However, trunk-shielded subjects that escaped the early death performed and survived longer than most head-shielded or unshielded pigs. ETI occurred in all of the trunk-shielded pigs that received 6000 rads and in one of four that received 3000 rads; however, early deaths did not occur and survival times were much longer than those previously reported for unshielded pigs that received comparable doses.

## I. INTRODUCTION

Incapacitation has been observed in monkeys,[2] dogs,[3] and miniature pigs[4] that received supralethal, pulsed doses of ionizing radiation. Over a fairly wide range of such doses, the pig and the monkey experienced a period of early transient incapacitation (ETI) from which they recovered to perform satisfactorily for several hours. ETI was not observed in the dog; after the onset of incapacitation, the dog's condition declined continually without improvement.

Head shielding and trunk shielding alleviated or prevented the symptoms of ETI for the monkey.[5] Head shielding prevented early incapacitation in the dog, but trunk shielding did not.[4] The purpose of this study was to determine whether head or trunk shielding would alleviate or prevent early incapacitation in irradiated miniature pigs.

## II. PROCEDURE

The subjects were trained miniature pigs (male, female, and barrow) of the Hormel-Hanford strain. At the time of exposure they weighed between 30 and 40 kg and were about 21 cm thick at the shoulder.

Thirty-two subjects were irradiated individually with the AFRRI-TRIGA reactor operated in the pulsed mode.[3] Eight unshielded pigs (whole-body exposed) received midline tissue doses (MTD) of about 13,000 rads of pulsed, mixed gamma-neutron radiations to the head and trunk. Eight head-shielded and eight trunk-shielded pigs received doses to the unshielded part of the body that were equivalent to the doses received by unshielded animals. Four trunk-shielded pigs received 6000 rads to the head and four others received 3000 rads to the head.

Each pig was restrained in a Plexiglas box and positioned with its left side toward the reactor core. The pig's center line was about 79 cm from the vertical core center line, and appropriate shielding of the type previously described[4] was in place. Immediately after exposure, the pig was released into a shuttlebox for performance testing.

Midline tissue doses to the head and trunk of each animal were calculated based on measurements in a pig cadaver (Figure 1). Depth-dose distributions in the pig cadaver are presented in Figures 2-4. Dosimetry methods were similar to those used in other experiments.[4,5] The midline tissue dose behind the shield (at the middle of the head or trunk) was less than 7 percent of the midline tissue dose to the same point without a shield in place. The whole-body exposures were

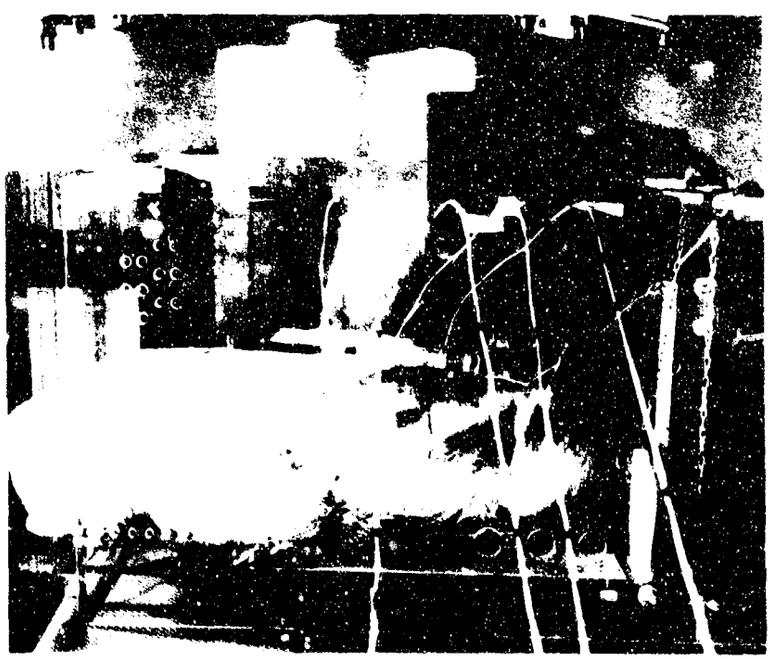

Figure 1. Array for depth-dose measurements in head-shielded pig cadaver

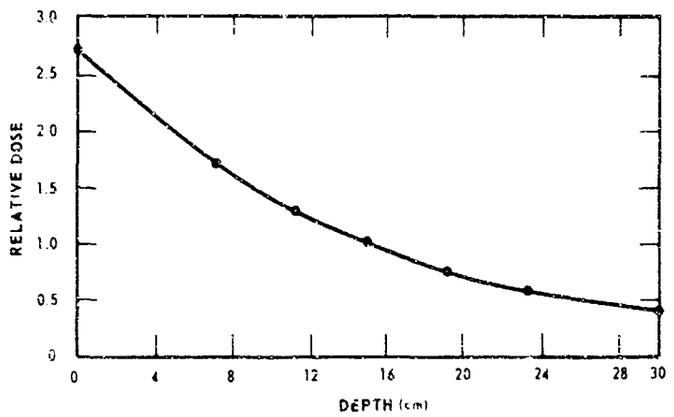


Figure 2. Horizontal depth-dose distribution through trunk of pig cadaver

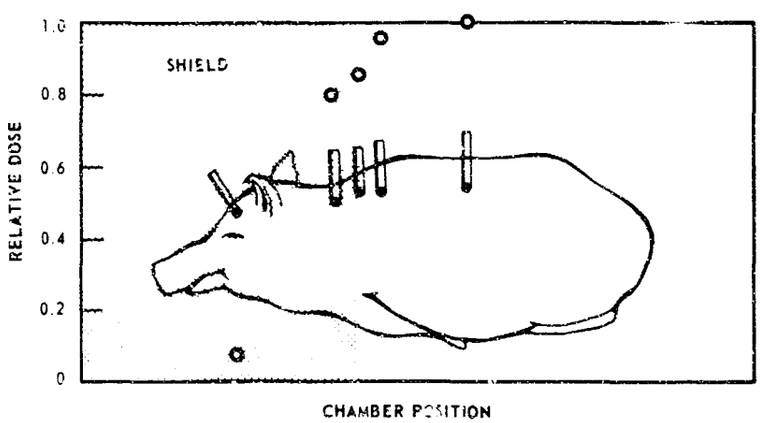


Figure 3. Longitudinal midline tissue dose distribution in head-shielded pig cadaver

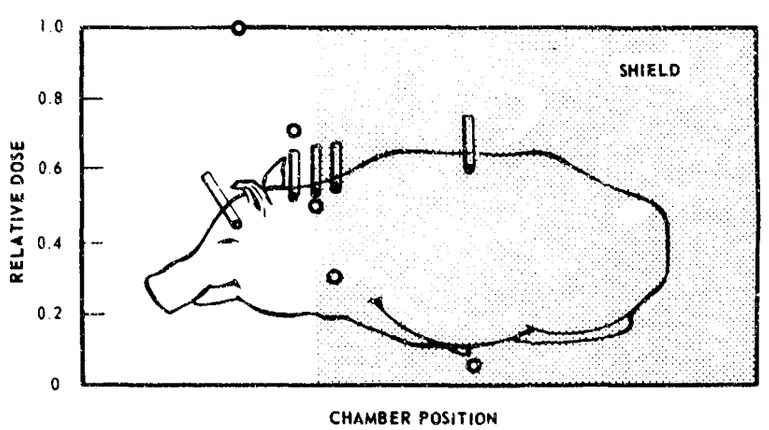


Figure 4. Longitudinal midline tissue dose distribution in trunk-shielded pig cadaver

Class B, nonuniform as defined in the International Commission on Radiological Units and Measurements Report 10e.

The pigs were trained by shock avoidance conditioning to traverse a two-chambered shuttlebox. The task is more completely described in another report.[1] Each trial lasted 15 seconds; beginning with the presentation of appropriate cues, the trial sequence allowed 6 seconds to avoid shock by traversing the shuttlebox, 3 seconds to escape from the shock by traversing the box, and 6 seconds to rest. Each subject was trained to a proficiency of at least 90 percent avoidance before it was irradiated.

Each postirradiation test period consisted of 10 trials. Test periods were initiated in the exposure room at 0, 3, 6, 9, 12, 15, 20, 25, 30, 35, 40, and 45 minutes after exposure. The pig was then removed from the exposure room and tested again at 1, 2.5, and 4 hours postexposure and every 2 hours thereafter until death.

## III. RESULTS

Results are summarized in Tables I through V. The subject was considered to have suffered ETI if there were any convulsions or if the pig was unable to avoid or escape for several consecutive trials.

Among the pigs receiving 13,000 rads, ETI or immediate, permanent complete incapacitation (PCI) occurred in all of the unshielded pigs and in seven of the eight trunk-shielded pigs; all of these animals suffered convulsions during the early part of ETI. The other trunk-shielded pig did not suffer ETI, but its early performance was far below preirradiation levels (85 avoidances for 130 trials after exposure,

Table I. Postirradiation Performance of Unshielded Pigs (13,000 rads)

| Pig number | First hour performance (130 trials) | | | Length of ETI (minutes) | Survival time (hours) | Last performance (hours) | Length of PCI (hours) |
|---|---|---|---|---|---|---|---|
| | Number of avoidances | Number of escapes | Avoidances and escapes | | | | |
| 1 | 30 | 8 | 38 | 30 | 3 | 2 | 1 |
| 2 | 92 | 5 | 97 | 9 | 19 | 12 | 7 |
| 3 | 69 | 14 | 83 | 12 | 16 | 11 | 5 |
| 4 | 81 | 6 | 87 | 12 | 32 | 26 | 6 |
| 5 | 0 | 0 | 0 | no recovery | 3 | none | |
| 6 | 0 | 0 | 0 | no recovery | 0.5 | none | |
| 7 | 0 | 2 | 2 | 45 | 20 | 12 | 8 |
| 8 | 46 | 20 | 66 | 20 | 4 | 3 | 1 |

Table II. Postirradiation Performance of Head-Shielded Pigs (13,000 rads)

| Pig number | First hour performance (130 trials) | | | Length of ETI (minutes) | Survival time (hours) | Last performance (hours) | Length of PCI (hours) |
|---|---|---|---|---|---|---|---|
| | Number of avoidances | Number of escapes | Avoidances and escapes | | | | |
| 1 | * | * | * | * | 109 | 96 | 13 |
| 2 | 125 | 5 | 130 | none | 88 | 80 | 8 |
| 3 | 129 | 1 | 130 | none | 19 | 13 | 6 |
| 4 | 118 | 11 | 129 | none | 28 | 24 | 4 |
| 5 | 129 | 1 | 130 | none | 25 | 17 | 8 |
| 6 | 121 | 7 | 128 | none | 32 | 21 | 11 |
| 7 | 121 | 9 | 130 | none | 33 | 30 | 3 |
| 8 | 84 | 6 | 90 | 12 | 95 | 92 | 3 |

* Pig was not released until 10 minutes postexposure. No indication of any type of early incapacitation.

Table III. Postirradiation Performance of Trunk-Shielded Pigs (13,000 rads)

| Pig number | First hour performance (130 trials) | | | Length of ETI (minutes) | Survival time (hours) | Last performance (hours) | Length of PCI (hours) |
|---|---|---|---|---|---|---|---|
| | Number of avoidances | Number of escapes | Avoidances and escapes | | | | |
| 1 | 85 | 14 | 99 | none * | 124 | 110 | 14 |
| 2 | 0 | 0 | 0 | no recovery | 0.45 | none | |
| 3 | 3 | 12 | 15 | 35 | 112 | 51 | 61 |
| 4 | 69 | 2 | 71 | 15 | 111 | 96 | 15 |
| 5 | 92 | 7 | 99 | 6 | 119 | 104 | 15 |
| 6 | 51 | 13 | 64 | 20 | 146 | 94 | 52 |
| 7 | 82 | 20 | 102 | 3 | 132 | 116 | 16 |
| 8 | 8 | 19 | 27 | 15 | 0.75 | 0.6 | |

* No ETI, but performance was below acceptable levels

Table IV. Postirradiation Performance of Trunk-Shielded Pigs (6,000 rads)

| Pig number | First hour performance (130 trials) | | | Length of ETI (minutes) | Survival time (hours) | Last performance (hours) | Length of PCI (hours) |
|---|---|---|---|---|---|---|---|
| | Number of avoidances | Number of escapes | Avoidances and escapes | | | | |
| 1 | 88 | 32 | 120 | 5 | 236 | 165 | 71 |
| 2 | 101 | 13 | 114 | 5 | 191 | 144 | 47 |
| 3 | 125 | 3 | 128 | 1 | 214 | 167 | 47 |
| 4 | 64 | 8 | 72 | 20 | 285 | 190 | 95 |

Table V. Postirradiation Performance of Trunk-Shielded Pigs (3,000 rads)

| Pig number | First hour performance (110 trials)* | | | Length of ETI (minutes) | Survival time (hours) | Last performance (hours) | Length of PCI (hours) |
|---|---|---|---|---|---|---|---|
| | Number of avoidances | Number of escapes | Avoidances and escapes | | | | |
| 1 | 107 | 2 | 109 | none | 359 | 284 | 75 |
| 2 | 83 | 18 | 101 | 3 | 312 | 283 | 29 |
| 3 | 94 | 6 | 100 | none | 310 | 282 | 28 |
| 4 | 107 | 3 | 110 | none | 280 | 257 | 23 |

* Pigs were removed from exposure room early because there was very little evidence of ETI

compared to 100 percent avoidances in preirradiation testing). One head-shielded pig suffered ETI without convulsions; its failures were apparently due to temporary paralysis of its hind legs. Three head-shielded pigs seemed slightly ataxic for 5 to 10 minutes after irradiation, but they did perform at acceptable levels. ETI also occurred in the four trunk-shielded pigs that received 6000 rads to the head and in one of the four trunk-shielded pigs that received 3000 rads to the head.

After receiving 13,000 rads, two unshielded pigs and one trunk-shielded pig suffered immediate PCI. All other pigs in this experiment either performed continously at acceptable levels for some time after irradiation or they recovered to perform satisfactorily after experiencing ETI. All pigs experienced PCI before death. For some pigs, the onset of PCI appeared to be delayed by head shielding

or trunk shielding. PCI appeared to last longer in trunk-shielded animals than in head-shielded or unshielded animals. PCI lasted several hours in the trunk-shielded pigs that received 6000 or 3000 rads.

Survival times of 4 hours or less were observed among unshielded and trunk-shielded pigs that received 13,000 rads to the head. These early deaths did not occur in head-shielded pigs of the 13,000-rad dose group nor in trunk-shielded pigs that received lower doses. Among the unshielded subjects in the high dose group, four survived 4 hours or less and four survived between 16 and 32 hours. Five of the head-shielded subjects survived between 19 and 33 hours and three survived between 88 and 109 hours. Two of the trunk-shielded pigs survived less than 1 hour after exposure, and the survival times of the other six ranged from 111 to 146 hours. Among the trunk-shielded pigs receiving lower doses, mean survival times were 231 hours for the 6000-rad group and 315 hours for the 3000-rad group.

## IV. DISCUSSION

The results of this study indicate that radiation damage to the head is the primary cause of the early death and early incapacitation observed in pigs. Among the pigs receiving 13,000 rads to the head, ETI accompanied by convulsions and some early deaths occurred whether the trunk was shielded or not. Furthermore, ETI occurred in one trunk-shielded pig that received only 3000 rads to the head. The latter finding is similar to earlier results[1] which indicate that ETI can occur after whole-body exposures if the head receives between 2500 and 4000 rads. By contrast, head shielding prevented convulsions and early deaths in all pigs, and ETI occurred in only one of eight animals.

Since one head-shielded pig did suffer temporary paralysis and three others were temporarily ataxic after irradiation, it may be that early incapacitation due to physical disability would occur in head-shielded pigs receiving higher doses to the trunk.

It appears that head shielding or trunk shielding can extend survival and effectiveness of irradiated pigs. Head shielding prevented early deaths, but the unshielded pigs that escaped early death lived and performed about as long as most head-shielded pigs. Trunk shielding did not completely prevent early deaths in the highest dose group, but the trunk-shielded subjects that escaped early deaths performed and survived longer than unshielded or head-shielded pigs. There were no early deaths among the trunk-shielded pigs that received lower doses, and these pigs performed and survived much longer than unshielded pigs that received comparable doses in another study.[1]

Head shielding offered some protection to dogs,[4] monkeys[5] and miniature pigs that received supralethal doses of pulsed mixed gamma-neutron radiations. Early death was prevented in all three species and early incapacitation was either absent or less severe when the head was shielded. Head shielding extended the survival time of dogs, but this effect was less apparent in head-shielded pigs or monkeys.

Trunk shielding seems to be generally less beneficial than head shielding for all three species. There appeared to be no benefit to dogs from trunk shielding, and ETI and early deaths did occur in some trunk-shielded pigs. However, trunk shielding prevented early deaths among irradiated monkeys, and the pigs and monkeys that escaped early deaths did live longer than most head-shielded or unshielded

subjects. Trunk shielding reduced the probability of ETI in monkeys, but, if a trunk-shielded monkey did suffer ETI, it was more severe than in the head-shielded monkey.

Some caution must be observed in comparing the three animal species. The response of unshielded animals varies among species, and different tasks and different doses were used in studying the three species. Furthermore, the head or trunk of the dog or pig could be more effectively shielded than the head or trunk of the monkey. It was necessary to work with large source dimensions and short source-to-animal distances in all three studies. The smaller size of the monkey, compared to that of the dog or pig, made it more difficult to shield one part of the body while irradiating another. It appears that more experiments should be completed using other radiation sources with which the monkey's head or trunk can be more effectively shielded. In addition, physiological and biochemical changes should be studied in all three species to help elucidate the mechanisms involved.

## REFERENCES


1. Chaput, R. L. and Wise, D. Miniature pig incapacitation and performance decrement after mixed gamma-neutron irradiation. Bethesda, Maryland, Armed Forces Radiobiology Research Institute Scientific Report SR69-12, 1969.

2. de Haan, H. J., Kaplan, S. J. and Germas, J. E. Visual discrimination performance in the monkey following a 5,000-rad pulse of mixed gamma-neutron radiation. Bethesda, Maryland, Armed Forces Radiobiology Research Institute Scientific Report SR69-1, 1969.

3. Pitchford, T. L. Beagle incapacitation and survival time after pulsed mixed gamma-neutron irradiation. Bethesda, Maryland, Armed Forces Radiobiology Research Institute Scientific Report SR68-24, 1968.

4. Thorp, J. W. Head shielding protection for beagles exposed to supralethal doses of pulsed mixed gamma-neutron radiations. Bethesda, Maryland, Armed Forces Radiobiology Research Institute Scientific Report SR68-26, 1968.

5. Thorp, J. W. and Germas, J. E. Performance of monkeys after partial body irradiation. Bethesda, Maryland, Armed Forces Radiobiology Research Institute Scientific Report SR69-18, 1969.

UNCLASSIFIED
Security Classification

**DOCUMENT CONTROL DATA - R&D**
*(Security classification of title, body of abstract and indexing annotation must be entered when the overall report is classified)*

| | |
|---|---|
| 1. ORIGINATING ACTIVITY (Corporate author)<br>Armed Forces Radiobiology Research Institute<br>Defense Atomic Support Agency<br>Bethesda, Maryland 20014 | 2a. REPORT SECURITY CLASSIFICATION<br>UNCLASSIFIED<br>2b. GROUP<br>N/A |

3. REPORT TITLE

PERFORMANCE OF MINIATURE PIGS AFTER PARTIAL BODY IRRADIATION

4. DESCRIPTIVE NOTES (Type of report and inclusive dates)

5. AUTHOR(S) (Last name, first name, initial)

Thorp, J. W., Chaput, R. L. and Kovacic, R. T.

| | | |
|---|---|---|
| 6. REPORT DATE<br>December 1969 | 7a. TOTAL NO. OF PAGES<br>19 | 7b. NO. OF REFS<br>5 |
| 8a. CONTRACT OR GRANT NO.<br>b. PROJECT NO.<br>c. MA 1 90406<br>d. | 9a. ORIGINATOR'S REPORT NUMBER(S)<br>AFRRI SR69-20<br>9b. OTHER REPORT NO(S) (Any other numbers that may be assigned this report) | |

10. AVAILABILITY/LIMITATION NOTICES

Distribution of this document is unlimited

| | |
|---|---|
| 11. SUPPLEMENTARY NOTES | 12. SPONSORING MILITARY ACTIVITY<br>Defense Atomic Support Agency<br>Washington, D. C. 20305 |

13. ABSTRACT

Thirty-two miniature pigs were trained by shock avoidance conditioning to traverse a two-chambered shuttlebox. Eight unshielded pigs (whole-body exposed) received midline tissue doses (MTD) of about 13,000 rads of pulsed, mixed gamma-neutron radiations to the head and trunk. Eight head-shielded and eight trunk-shielded pigs received doses to the unshielded part of the body that were equivalent to the doses received by unshielded animals. Four trunk-shielded pigs received 6000 rads to the head, and four others received 3000 rads to the head. MTD behind the shield (at the middle of the head or trunk) was less than 7 percent of the MTD to the same point without a shield in place. Postirradiation performance was evaluated. All unshielded pigs suffered early transient incapacitation (ETI) or immediate, permanent complete incapacitation (PCI); several early deaths (within 4 hours) occurred among these animals. Head shielding prevented ETI, immediate PCI, and early deaths, but trunk shielding did not. However, trunk-shielded subjects that escaped the early death performed and survived longer than most head-shielded or unshielded pigs. ETI occurred in all of the trunk-shielded pigs that received 6000 rads and in one of four that received 3000 rads; however, early deaths did not occur and survival times were much longer than those previously reported for unshielded pigs that received comparable doses.

DD FORM 1473

UNCLASSIFIED
Security Classification

UNCLASSIFIED
Security Classification

| 14 KEY WORDS | LINK A ROLE | LINK A WT | LINK B ROLE | LINK B WT | LINK C ROLE | LINK C WT |
|---|---|---|---|---|---|---|
| | | | | | | |

INSTRUCTIONS

1. ORIGINATING ACTIVITY: Enter the name and address of the contractor, subcontractor, grantee, Department of Defense activity or other organization (*corporate author*) issuing the report.

2a. REPORT SECURITY CLASSIFICATION: Enter the overall security classification of the report. Indicate whether "Restricted Data" is included. Marking is to be in accordance with appropriate security regulations.

2b. GROUP: Automatic downgrading is specified in DoD Directive 5200.10 and Armed Forces Industrial Manual. Enter the group number. Also, when applicable, show that optional markings have been used for Group 3 and Group 4 as authorized.

3. REPORT TITLE: Enter the complete report title in all capital letters. Titles in all cases should be unclassified. If a meaningful title cannot be selected without classification, show title classification in all capitals in parenthesis immediately following the title.

4. DESCRIPTIVE NOTES: If appropriate, enter the type of report, e.g., interim, progress, summary, annual, or final. Give the inclusive dates when a specific reporting period is covered.

5. AUTHOR(S): Enter the name(s) of author(s) as shown on or in the report. Enter last name, first name, middle initial. If military, show rank and branch of service. The name of the principal author is an absolute minimum requirement.

6. REPORT DATE: Enter the date of the report as day, month, year; or month, year. If more than one date appears on the report, use date of publication.

7a. TOTAL NUMBER OF PAGES: The total page count should follow normal pagination procedures, i.e., enter the number of pages containing information.

7b. NUMBER OF REFERENCES: Enter the total number of references cited in the report.

8a. CONTRACT OR GRANT NUMBER: If appropriate, enter the applicable number of the contract or grant under which the report was written.

8b, 8c, & 8d. PROJECT NUMBER: Enter the appropriate military department identification, such as project number, subproject number, system numbers, task number, etc.

9a. ORIGINATOR'S REPORT NUMBER(S): Enter the official report number by which the document will be identified and controlled by the originating activity. This number must be unique to this report.

9b. OTHER REPORT NUMBER(S): If the report has been assigned any other report numbers (*either by the originator or by the sponsor*), also enter this number(s).

10. AVAILABILITY/LIMITATION NOTICES: Enter any limitations on further dissemination of the report, other than those imposed by security classification, using standard statements such as:

(1) "Qualified requesters may obtain copies of this report from DDC."

(2) "Foreign announcement and dissemination of this report by DDC is not authorized."

(3) "U. S. Government agencies may obtain copies of this report directly from DDC. Other qualified DDC users shall request through _____."

(4) "U. S. military agencies may obtain copies of this report directly from DDC. Other qualified users shall request through _____."

(5) "All distribution of this report is controlled. Qualified DDC users shall request through _____."

If the report has been furnished to the Office of Technical Services, Department of Commerce, for sale to the public, indicate this fact and enter the price, if known.

11. SUPPLEMENTARY NOTES: Use for additional explanatory notes.

12. SPONSORING MILITARY ACTIVITY: Enter the name of the departmental project office or laboratory sponsoring (*paying for*) the research and development. Include address.

13. ABSTRACT: Enter an abstract giving a brief and factual summary of the document indicative of the report, even though it may also appear elsewhere in the body of the technical report. If additional space is required, a continuation sheet shall be attached.

It is highly desirable that the abstract of classified reports be unclassified. Each paragraph of the abstract shall end with an indication of the military security classification of the information in the paragraph, represented as (TS), (S), (C), or (U).

There is no limitation on the length of the abstract. However, the suggested length is from 150 to 225 words.

14. KEY WORDS: Key words are technically meaningful terms or short phrases that characterize a report and may be used as index entries for cataloging the report. Key words must be selected so that no security classification is required. Identifiers, such as equipment model designation, trade name, military project code name, geographic location, may be used as key words but will be followed by an indication of technical context. The assignment of links, rules, and weights is optional.