UR-440

THE RELATIONSHIP BETWEEN SURFACE GRADE AND DEPTH OF
DAMAGE OF BURNS PRODUCED BY RADIANT THERMAL ENERGY

by

J. R. Hinshaw
H. W. Bales
H. E. Pearse

THE UNIVERSITY OF ROCHESTER
ATOMIC ENERGY PROJECT
ROCHESTER, NEW YORK

DISCLAIMER

This report was prepared as an account of work sponsored by an agency of the United States Government. Neither the United States Government nor any agency Thereof, nor any of their employees, makes any warranty, express or implied, or assumes any legal liability or responsibility for the accuracy, completeness, or usefulness of any information, apparatus, product, or process disclosed, or represents that its use would not infringe privately owned rights. Reference herein to any specific commercial product, process, or service by trade name, trademark, manufacturer, or otherwise does not necessarily constitute or imply its endorsement, recommendation, or favoring by the United States Government or any agency thereof. The views and opinions of authors expressed herein do not necessarily state or reflect those of the United States Government or any agency thereof.

DISCLAIMER

Portions of this document may be illegible in electronic image products. Images are produced from the best available original document.

0

U N C L A S S I F I E D

UR-440

Health and Biology

THE UNIVERSITY OF ROCHESTER
Atomic Energy Project
P. O. Box 287, Station 3
Rochester 20, New York

* * *

Contract W-7401-eng-49 between the U. S. Atomic
Energy Commission and the University of Rochester,
administered by the Department of Radiation Biology
of the School of Medicine and Dentistry.

THE RELATIONSHIP BETWEEN SURFACE GRADE AND DEPTH OF
DAMAGE OF BURNS PRODUCED BY RADIANT THERMAL ENERGY

by

J. R. Hinshaw
H. W. Bales
H. E. Pearse

Division: Special Programs

Division Head: H. A. Blair

Section: Flash Burns

Section Head: J. R. Hinshaw

Date Completed: 3/26/56

Date of Issue: 4/10/56

U N C L A S S I F I E D

1

THE RELATIONSHIP BETWEEN SURFACE GRADE AND DEPTH OF
DAMAGE OF BURNS PRODUCED BY RADIANT THERMAL ENERGY.

By

J. R. Hinshaw
H. W. Bales
H. E. Pearse

ABSTRACT

The relationship between surface grade and depth of injury of burns produced on bare porcine skin by radiant thermal energy has been investigated. Surface grades of 1+ and 2+ correlate well with depth of injury independently of exposure time, but a grade of 3+ does not, except for very short exposure times. The depth of 4+ burns, and of 3+ burns from long exposures, can be determined only by microscopic examination of the tissue.

)

INTRODUCTION

The relationship between the surface appearance and the depth of damage of burns produced by radiant thermal energy has previously been investigated in this laboratory (1, 2, 3). This work has indicated a nearly constant relationship between the two in mild burns, but little correlation between them in more serious injuries. The results of the effect of exposure time have not been consistent. One investigator (2) found that exposure time has little effect on the relationship between appearance and damage while another (3) believed that there are marked differences due to exposure time in more severe burns.

Surface grading of burns can be accomplished much more rapidly and inexpensively than can microscopic examination of biopsies. It is therefore important to know how much reliance can be placed on surface grading data, and to learn when, if ever, it is essential to determine the depth of damage by histological methods. Wherever there is good correlation between the two, much time and effort can be saved by surface grading alone. Wherever this correlation breaks down, the extra effort must be expended before the data become meaningful.

In an effort to clarify this problem, the relationship between surface appearance and depth of damage has been re-investigated.

METHODS

Chester White pigs, anesthetized with intraperitoneal Dial in Urea-urethane (Ciba) in doses of 70 mgm/Kg of body weight were used as the experimental animals. The heat source was a modified 24 inch Army carbon arc searchlight (3, 4). Three exposure times were selected, 0.3, 3.0 and 30.0 seconds. The appropriate number of calories to be delivered at each

exposure time was determined by a pilot study. In this way a sufficient number of burns of each surface grade from 1+ to 4+ was insured. In order to stress the fact that this study is a comparison of surface grade and depth of damage without regard to the actual exposures producing the injuries, the irradiances and exposures used are not listed. However, it may be said that from five to nine irradiances, separated by 10% increments, contribute to the data for each condition of exposure time and surface grade.

Eighteen to 24 hours after burning, surface grades were assigned by using the following criteria (5):

- 1+ - Erythematous burn
- 2+ - Patchy, white burn
- 3+ - Uniform, white burn
- 4+ - Steam bleb or loss of dermal
resistance to point pressure

There were insufficient 5+ burns (carbonized burns) for analysis.

All burns were graded independently by at least two observers and, with few exceptions, complete agreement was noted. Whenever there was a discrepancy in the assigned grade, a more careful examination of the burn was conducted; this invariably led to agreement.

Immediately following the surface assessment, biopsies of the burns were taken. Some tissues were stained with hematoxylin and eosin and others were prepared by the method of Hinshaw (6) which demonstrates much more clearly the differences between damaged and normal tissues.

In evaluation of the microscopic pathology the most severe injury found is the one recorded. In the very mild burns damage is listed as

either "partial epidermal damage" or "complete epidermal damage" depending on whether or not there is evidence of either injury to the basal layer of epithelium or separation of the epidermis and dermis. The extent of damage into the tissues below the epidermis is measured with the aid of an ocular micrometer scale marked with 130 units to the millimeter. The results are tabulated in tenths of a millimeter since a more minute grading system would have no practical importance.

RESULTS

The results of this study of 471 burns are given in Table I and are presented graphically in Fig. 1. It can be seen that there is a very good correlation between a reading of 1+ and the depth of damage, and that exposure time makes little difference in the results. The slight differences noted can, for the most part, be ignored. They can easily be accounted for by the fact that many of the 0.3 sec. burns were 1+ mild and more of the 3.0 and 30.0 sec. burns were 1+ severe. It may be said that a reading of 1+ represents either partial or complete epidermal damage and that dermal damage, when it does occur, is quite superficial.

A 2+ burn is almost always indicative of at least complete epidermal damage and it more than likely will show some superficial dermal damage. Again, when it is considered that these lesions represent 2+ mild, 2+ moderate and 2+ severe burns, the 2+ burn seems to represent a relatively narrow range of injury regardless of the exposure time.

The 3+ burns, on the other hand, show that exposure time makes a considerable difference in the correlation between grade and depth. The 0.3 sec. burns are grouped closely so that we might expect most 3+ burns at this exposure time to represent dermal damage between 0.1 and 0.5 mm in

TABLE I

DEPTH OF DAMAGE FOR EACH EXPOSURE TIME AND SURFACE GRADE

Sur- face Grade	Expos- ure Time (sec)	Partial Epider- mal Damage	Complete Epider- mal Damage	*0- .1	.1- .2	.2- .3	.3- .4	.4- .5	.5- .6	.6- .7	.7- .8	.8- .9
1+	0.3	45 50%	29 32%	11 12%	3 3%	1 1%	1 1%					
	3.0	3 18%	8 47%	5 29%	1 6%							
	30.0	6 25%	14 59%	2 8%	2 8%							
2+	0.3	3 4%	17 21%	31 39%	18 23%	7 9%	2 2%	2 2%				
	3.0		9 31%	7 24%	6 21%	3 10%	1 4%	1 4%			1 4%	
	30.0	4 16%	11 44%	6 24%	2 8%	1 4%		1 4%				
3+	0.3			2 4%	7 15%	10 21%	15 32%	8 17%	5 11%			
	3.0		1 3%	3 9%	1 3%	1 3%	3 9%	1 3%		3 9%	7 20%	3 9%
	30.0		1 4%	2 8%	2 8%	1 4%	2 8%	1 4%	5 19%	2 8%	3 11%	
4+	0.3					8 24%	11 33%	7 21%	1 3%	2 6%	1 3%	1 3%
	3.0			1 3%	1 3%	1 3%	2 5%		1 3%	2 5%		3 8%
	30.0						1 4%	2 7%			1 4%	2 7%

*Damage beyond dermal epidermal junction expressed in millimeters.

TABLE I (Continued)

.9- 1.0	1.0- 1.1	1.1- 1.2	1.2- 1.3	1.3- 1.4	1.4- 1.5	1.5- 1.6	1.6- 1.7	1.7- 1.8	1.8- 1.9	1.9- 2.0	2.0- 3.0	3.0 4.0	Total Num- ber Burns
													90
													17
													24
													80
			1 4%										29
													25
													47
1 3%	5 14%	2 6%	2 6%	1 3%			1 3%						35
4 15%	1 4%	1 4%					1 3%						26
1 3%	1 3%												33
2 5%	2 5%	2 5%	4 11%	5 14%	2 5%	3 8%	1 3%	1 3%	2 5%		2 5%		37
2 7%		1 4%	2 7%	2 7%	1 4%		3 11%		1 4%	2 7%	6 21%	2 7%	28

7

RELATIONSHIP BETWEEN SURFACE GRADE AND DEPTH OF DAMAGE OF RADIANT THERMAL BURNS.

FIGURE 1

P = PARTIAL EPIDERMAL DAMAGE.

C = COMPLETE EPIDERMAL DAMAGE

* = A DEPTH GREATER THAN 2.0 mm., WHICH ALWAYS MEANS FULL THICKNESS DERMAL DAMAGE, IS NOT REPRESENTED GRAPHICALLY.

7

depth. 3+ burns produced by 3.0 and 30.0 sec. exposures, however, exhibit such a variety in their microscopic pathology that one cannot expect to guess the extent of these injuries.

The 4+ burns are quite similar to the 3+ burns. When produced by 0.3 sec. exposures they most likely will represent dermal injury between 0.2 and 0.5 mm in depth; a few will extend more deeply. The longer exposure times produce a wide, unpredictable range of damage.

DISCUSSION

It would appear from the results of this work that there is excellent correlation between depth of injury and surface grade of the less severe burns. The grades of 1+ and 2+ exhibit a narrow, predictable range of injury, and for the purposes of many experiments the more time-consuming and expensive microscopic evaluation is not necessary. With very short exposure times the depth of injury of 3+ and 4+ burns is also fairly predictable.

With the longer exposure times, 3+ and 4+ burns may represent such a wide range of injury that microscopic evaluation is essential to lend meaning to experimental work on these lesions.

It has previously been pointed out (7) that the milder burns cause little distortion of the tissue either by edema formation or shriveling of the dermis. More severe burns, however, do produce tissue changes which nullify the usefulness of the measurement of depth of injury in millimeters. 1+, 2+ and 3+ burns almost never represent severe distortions of the tissue, and depth of injury is a useful measurement for comparing these lesions one with another. On the other hand, 4+ and 5+ burns (7, 8) produce variable responses in the tissues. For the most part these

burns, produced by very short exposures, show a shriveling of the tissues. A depth of damage of no more than 0.7 mm may represent destruction of the entire thickness of the dermis. With longer exposure times, a depth of injury twice this great may represent incomplete dermal damage particularly if edema is prominent. It has also been shown (8) that a 5+ burn produced by a short exposure time may represent either a relatively superficial injury or a very deep one. For these reasons experiments with more severe burns, those with a surface grade of 4+ and 5+, should include microscopic examination no matter what exposure time is being investigated.

SUMMARY AND CONCLUSIONS

1. Four hundred seventy-one burns have been analyzed to determine the relationship between surface grade and depth of damage.
2. Surface grades of 1+ and 2+ represent a reasonably predictable depth of injury, and for many experiments microscopic examination of the burns will not be necessary for evaluation of data on these lesions. Exposure times of 0.3, 3.0 and 30.0 sec. show similar results.
3. A surface grade of 3+ represents a predictable depth of injury only in burns produced by very short exposure times.
4. Experimental work on 4+ and 5+ burns should always include microscopic examination of the lesions because both the depth and the nature of the injury are unpredictable.

BIBLIOGRAPHY

1. Perkins, J. B., Kingsley, H. D., and Pearse, H. E., A Study of Radiant Energy Burns: The Effect of Exposure Time and Intensity, Univ. of Roch. Atomic Energy Project Report, UR-217, (1952).
2. Berkley, K. M., Study on Flash Burns: Evaluation of Surface Appearance of Burns by Depth of Damage, Univ. of Roch. Atomic Energy Project Report, UR-337, (1954).
3. Lyon, J. L., Davis, T. P., and Pearse, H. E., Studies of Flash Burns: The Relation of Thermal Energy Applied and Exposure Time to Burn Severity, Univ. of Roch. Atomic Energy Project Report, UR-394, (1955).
4. Davis, T. P., Krolak, L. J., Blakney, R. M., and Pearse, H. E., Modification of the Carbon Arc Searchlight for Producing Experimental Flash Burns, J.O.S.A., 44: 766-769, (1954).
5. Bales, H. W., Hinshaw, J. R., and Pearse, H. E., A Comparison of the Effects of Radiant Thermal Energy on Bare, Blackened and Whitened Pig Skin, Univ. of Roch. Atomic Energy Project Report, UR-438, (1956).
6. Hinshaw, J. R. (In preparation), (1956).
7. Hinshaw, J. R., Some Effects of Superimposing Two Radiant Energy Thermal Burns on Bare Porcine Skin, Part I, Part II, Part III, Univ. of Roch. Atomic Energy Project Report, UR-433, (1956).
8. Bales, H. W., Roth, R. E., Krolak, L. J., and Pearse, H. E., Evaluation of Magnesium Powder as a Source for the Production of Large Area Flash Burns on Pig Skin, Univ. of Roch. Atomic Energy Project Report, UR-436, (1956).