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STUDY ON FLASH BURNS: EVALUATION OF SURFACE
APPEARANCE OF BURNS BY DEPTH OF DAMAGE

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STUDY ON FLASH BURNS:
EVALUATION OF SURFACE APPEARANCE OF BURNS
BY DEPTH OF DAMAGE

By

K. M. Berkley

ABSTRACT

Burns produced on the pig by the carbon arc source alone and modified by two filters one eliminating all wavelengths below $3340 \text{ \AA}$, the other below $6170 \text{ \AA}$ at exposure times of 0.5, 1.0, 2.0 and 4.0 sec. were graded by surface appearance in the following manner. 1+ burns are erythematous lesions, 2+ burns show in the mildest form small spots of whiteness scattered over a red background. As the severity increases the spots become confluent. When an area of one cm^2 appears completely white, the laboratory grade of a 3+ burn is reached. Each grade of severity was further divided into mild, moderate and severe subgroups. The burns were also evaluated histologically by depth of damage. It was found that a burn as judged by surface appearance in the grades of 1+ moderate to 3+ mild showed similar microscopic changes in each subgroup regardless of the exposure time or the wavelength distribution of energy used.

A table is given which will serve as a guide to the depth of damage which will be found in a given burn when graded by its surface appearance for exposure times of 0.5 to 4.0 sec.

INTRODUCTION

The relationship between the surface appearance and the depth of damage of a burn is of fundamental importance. Two arbitrary classifications in this laboratory have been developed for burns produced in the pig, one for surface appearance and the other for depth of damage (5). However, a direct comparison of the relationship has been reported only for one second exposures (4).

This report compares the surface and depth changes of burns produced by the carbon arc source, unmodified and modified by two filters, at four exposure times, 0.5, 1.0, 2.0 and 4.0 seconds. The effect of the wavelength on the severity of the burns has been reported previously (1).

METHODS AND EQUIPMENT

Equipment

An Army 24" carbon arc searchlight modified by an ellipsoidal mirror as described (2) was used to furnish radiant energy of high intensity.

The spectral qualities of the arc beam were modified by two 3-1/8" square filter glasses mounted 1-1/2" from the exposure plane. The specifications of these filters are as follows:

No. 1. The #7380 filter glass, designated H. R. Nultra, C. S. O-52, has less than 0.25% transmission at 3340 Å and greater than 60% at 3650 Å. It transmits approximately 90% of light from 4000 Å to 25,000 Å.

No. 2. The #2403 filter glass, H. R. red shade 3, C. S. 2-58 has a cut-off at 6370-6480 Å and transmits 88% over most of its range to 25,000 Å.

Equipment and Design

In one group of animals 38 treatments were used with exposure times from 0.5 to 4.0 sec. with the two filter glasses, and varying the radiant exposures as indicated in table 1. The treatments were randomized on the sides of 21 animals using an incomplete block design.

In a separate group of animals 24 treatments were systematically randomized on both sides of four animals, such that one exposure occurred on each side of an animal with equal probability of its falling in any one of 24 subareas on the side. Six irradiances at each of four exposure times from 0.5 to 4.0 sec. were used with the carbon arc source unmodified.

Animals

Chester White pigs weighing approximately 10 kg were used. Prolonged anesthesia was obtained with Dial in Urea-urethane (Ciba) 70-75 mg per Kg body weight, given by the intraperitoneal route (3). The skin was closely clipped, washed and dried before burning.

Evaluation

A. Surface Appearance

The lesions were evaluated 24 hours after production and were graded 0, 1+, 2+ and 3+. 0 designates no burn; 1+ a red burn; 2+, one in which there are first small spots of white scattered over an erythematous area; 3+, one in which a burned area one cm² was completely white. Each numbered category was further divided into mild, moderate and severe subgroups.

B. Depth of Damage

After evaluation of the surface appearance, 581 lesions were biopsied and fixed in Bouin's solution, and stained by hemotoxylin and eosin. The burns were graded as previously described (5) noting the following features. The first obvious change is acidophilism of the epidermal cells. Part, or all, of the depth of the epidermis may be involved. As the energy increases, the epidermis begins to show gross distortion of its cells and to separate from the dermis. This is at first incomplete, over the exposed surface, progressing to complete separation. These are termed transepidermal burns. As the severity increases, a line of horizontal demarcation develops between the damaged, glassy appearing dermis and the underlying tissue. This change was observed only in the superficial layers of the dermis in this experiment.

The criteria then are epidermal acidophilism, transepidermal damage either focally or completely, and dermal damage.

RESULTS

For each grade of burn as judged by surface appearance, the number and percent of burns falling into each category based on depth of damage was determined. This was done separately at each exposure time and for each type of radiation. These results are shown in table 2 and graphically represented as frequency polygons in figures 1, 2 and 3 for the three types of radiation.

From table 2 the following descriptions can be made. The 1+ moderate burns, when examined histologically show epidermal acidophilism and focal transepidermal damage. The 1+ severe burn shows approximately the

same picture. The 2+ mild burn shows in almost every instance focal transepidermal or more damage. There are only two isolated instances in which only epidermal acidophilism was the only feature. Such a description is thus tabulated for each criterion of surface appearance.

In figure 1, 2 and 3 it can be seen that the depth of damage for any grade of burn judged by surface appearance is relatively independent of exposure time. Therefore, the percent of burns as graded by surface appearance falling into the categories based on depth of damage were plotted for each of the three types of radiation irrespective of exposure time in figure 4, which shows that type of radiation has little influence on the relationship of surface appearance and depth of damage.

Table 3 is a summary of the data depicting the depth of damage of any type of burn graded by surface appearance, regardless of the energy, type of radiation or exposure time used to produce the lesion. It then serves as a guide to the depth of damage which will be found in a given burn when graded by its surface appearance. These data are shown graphically in figure 5.

The change in histological picture is very slight between successive grades. For 1+ moderate and 1+ severe burns 25% show epidermal acidophilism and 75% focal transepidermal or more severe damage. As the severity increases to a 2+ mild burn, 1% show epidermal acidophilism, 99% focal transepidermal or more severe damage. 2+ moderate, 2+ severe and 3+ mild burns show an increasing amount of complete transepidermal and dermal damage. 33% of 2+ moderate burns, 60% of 2+ severe burns and 91% of 3+ mild burns show complete transepidermal damage or more.

The grade of surface appearance at which all burns showed complete transepidermal or more damage was not reached in this experiment and is greater than 3+ mild.

SUMMARY AND CONCLUSIONS

1. Five hundred eighty-one burns produced by the carbon arc source unmodified and modified by two filter glasses at 0.5, 1.0, 2.0 and 4.0 sec. exposure times were evaluated by surface appearance and microscopic changes. For each grade of burn as graded by surface appearance, the frequency of the microscopic changes was shown for each combination of exposure time and type of radiation used.

2. It was shown that neither exposure time nor type of radiation had much effect on the frequency of microscopic changes for any grade of burn as judged by surface appearance.

3. The frequency distributions of microscopic changes were shown for each grade of burn as judged by surface appearance.

a. Of 1+ moderate and 1+ severe burns, about 25% show epidermal acidophilism and 75% focal transepidermal or more damage. Of 2+ mild burns 1% show epidermal acidophilism and 99% focal transepidermal or more damage.

b. 2+ moderate, 2+ severe and 3+ mild burns show an increasing amount of complete transepidermal and dermal damage; 33% of 2+ moderate burns, 60% of 2+ severe burns and 91% of 3+ mild burns show complete transepidermal damage or more.

c. The grade of surface appearance at which all burns showed complete transepidermal or more damage was not reached on this experiment and is greater than 3+ mild.

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Table 1

DESIGN OF EXPERIMENT

Exposure Time	Radiant Exposure (cal/cm ²)		
	Filter #7380	Filter #2403	Unmodified
0.5	4.2 4.7 5.1 5.8 6.5 7.2	5.1 5.8 6.1 6.5 7.1 -	2.8 3.3 4.0 4.7 5.5 6.5
1.0	5.0 5.4 5.9 6.6 - -	6.7 7.0 7.4 8.0 9.0 10.3	3.2 3.7 4.7 5.7 6.3 6.7
2.0	5.9 6.3 7.4 8.0 - -	8.0 8.6 9.4 10.2 - -	4.0 4.5 7.0 7.6 8.0 9.0
4.0	6.5 7.0 7.5 8.1 - -	8.4 9.0 9.6 10.4 11.2 12.0	5.2 6.0 7.0 8.2 9.6 10.6

Table 2

THE RELATIONSHIP BETWEEN SURFACE APPEARANCE AND DEPTH OF DAMAGE

Surface Appearance	Time (sec)	Source	Epidermal Acidophilism	Transepidermal Damage		Dermal Damage Superficial	Total No. of Lesions Biopsied
				Focal	Complete		
1+ Mod.	0.5	Filter 1		6 (100%)			6
	1.0		2 (25%)	5 (63%)	1 (12%)		8
	2.0		1 (25%)	3 (75%)			4
	4.0			8 (100%)			8
	0.5	Filter 2	5 (33%)	9 (60%)		1 (7%)	15
	1.0		2 (25%)	4 (50%)	2 (25%)		8
	2.0		2 (25%)	6 (75%)			8
	4.0				1 (100%)		1
	0.5	Unmodified	1 (17%)	4 (67%)		1 (17%)	6
	1.0		4 (67%)	2 (33%)			6
	2.0		3 (50%)	3 (50%)			6
	4.0		5 (82%)	2 (20%)			7
1+ Sev.	0.5	Filter 1	1 (33%)	2 (67%)			3
	1.0			7 (100%)			7
	2.0		3 (25%)	8 (67%)	1 (8%)		12
	4.0		8 (27%)	21 (70%)		1 (3%)	30
	0.5	Filter 2	2 (14%)	12 (86%)			14
	1.0		3 (15%)	16 (80%)	1 (5%)		20
	2.0		6 (16%)	26 (70%)	4 (11%)	1 (3%)	37
	4.0		6 (19%)	24 (75%)	2 (6%)		32
	0.5	Unmodified		3 (100%)			3
	1.0		2 (50%)	2 (50%)			4
	2.0		1 (33%)	1 (33%)	1 (33%)		3
	4.0			2 (100%)			2
2+ Mild	0.5	Filter 1		12 (63%)	5 (26%)	2 (10%)	19
	1.0		1 (5%)	18 (86%)	2 (9%)		21
	2.0			17 (100%)			17
	4.0			17 (77%)	5 (23%)		22
	0.5	Filter 2	1 (12%)	7 (88%)			8
	1.0			8 (100%)			8
	2.0			12 (100%)			12
	4.0			8 (80%)	1 (10%)	1 (10%)	10
	0.5	Unmodified		2 (50%)	2 (50%)		4
	1.0			1 (25%)	2 (50%)	1 (25%)	4
	2.0			4 (80%)	1 (20%)		5
	4.0			4 (67%)	1 (17%)	1 (17%)	6
2+ Mod.	0.5	Filter 1		7 (78%)	1 (11%)	1 (11%)	9
	1.0			2 (28%)	4 (57%)	1 (14%)	7
	2.0		1 (7%)	11 (73%)	3 (20%)		15
	4.0			4 (50%)	2 (25%)	2 (25%)	8
	0.5	Filter 2		4 (100%)			4
	1.0			5 (71%)	2 (28%)		7
	2.0			5 (83%)	1 (17%)		6
	4.0			2 (100%)			2
	0.5	Unmodified			1 (100%)		1
	1.0			1 (17%)	5 (83%)		6
	2.0			6 (86%)	1 (14%)		7
	4.0			1 (50%)	1 (50%)		2
2+ Sev.	0.5	Filter 1		1 (8%)	9 (69%)	3 (23%)	13
	1.0			1 (25%)	3 (75%)		4
	2.0			2 (33%)	4 (67%)		6
	4.0		1 (50%)			1 (50%)	2
	0.5	Filter 2					0
	1.0			2 (29%)	5 (71%)		7
	2.0		1 (11%)	4 (44%)	4 (44%)		9
	4.0			2 (50%)	2 (50%)		4
	0.5	Unmodified			4 (67%)	2 (23%)	6
	1.0			2 (29%)	4 (57%)	1 (14%)	7
	2.0			2 (50%)	1 (25%)	1 (25%)	4
	4.0			1 (20%)	3 (60%)	1 (20%)	5
3+ Mild	0.5	Filter 1		1 (25%)	2 (50%)	1 (25%)	4
	1.0						0
	2.0			1 (17%)	5 (83%)		6
	4.0				1 (50%)	1 (50%)	2
	0.5	Filter 2					0
	1.0				2 (100%)		2
	2.0			1 (33%)	2 (67%)		3
	4.0						0
	0.5	Unmodified			6 (67%)	3 (33%)	9
	1.0				5 (71%)	2 (29%)	7
	2.0			1 (12%)	6 (75%)	1 (12%)	8
	4.0				1 (25%)	3 (75%)	4

Table 3

THE RELATIONSHIP BETWEEN SURFACE APPEARANCE AND DEPTH OF DAMAGE

Surface Appear- ance	Epidermal Acidophilism	Transepidermal Damage		Super- ficial Dermal	Total
		Focal	Complete		
1+ Mod.	25 (30%)	52 (63%)	4 (5%)	2 (2%)	83
1+ Sev.	32 (17%)	124 (74%)	9 (5%)	2 (1%)	167
2+ Mild	2 (1%)	110 (81%)	19 (14%)	5 (4%)	136
2+ Mod.	1 (1%)	48 (65%)	21 (28%)	4 (5%)	74
2+ Sev.	2 (3%)	17 (25%)	39 (58%)	9 (13%)	67
3+ Mild		4 (9%)	30 (67%)	11 (24%)	45

Figure 1

The frequency of histological changes of typical burns of stated surface appearance by radiation produced by the carbon arc source.

Figure 2

The frequency of histological changes of typical burns of stated surface appearance by radiation modified by filter 1.

Figure 3

The frequency of histological changes of typical burns of stated surface appearance by radiation modified by filter 2.

Figure 4

This figure shows the frequency of histological changes of typical burns of stated surface appearance disregarding exposure time for the 3 types of radiation employed.

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Figure 5

This figure shows the frequency of histological changes of typical burns of stated surface appearance.