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STUDY ON FLASH BURNS:

EVALUATION OF SIMULTANEOUS MONITORING OF THE CARBON ARC SOURCE

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STUDY ON FLASH BURNS:

EVALUATION OF SIMULTANEOUS MONITORING OF THE CARBON ARC SOURCE

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Kelly M. Berkley
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A monitoring apparatus has been used with the carbon arc source in producing cutaneous burns in the pig. Its use in the evaluation of dose-effect experiments was tested by comparison of the 50% effective exposures for 1+, 2+, 3+ and 4+ burns when the irradiance value was determined (1) by the monitor response simultaneously with burning, and (2) by predetermined calibration curves of movable diaphragms along the optical bench of the carbon arc. It was found that there was no significant difference in the 50% effective exposure using either method of determining the irradiance value.

It is concluded that the monitoring apparatus is not of practical value in evaluating radiant exposure-effect experiments.

INTRODUCTION

The physical factors influencing the production of cutaneous burns caused by short exposures to high intensity radiant energy encountered in atomic explosions have been of primary interest.

In the laboratory the modified 24" Corps of Engineers carbon arc searchlight (1) has been a versatile and controllable thermal source for these studies.

The energy derived from the source is measured with a radiation calorimeter at the exposure plane and calibrated against settings of movable diaphragms along an optical bench. Past experience has shown that at a given diaphragm setting, the irradiance ($\text{cal}/\text{cm}^2/\text{sec}$) can have a time variation of $\pm 10\%$. It seemed that a monitoring apparatus might be useful in reducing the uncertainty in the irradiance value at the actual time of exposure.

The following study was done to determine whether or not the monitoring apparatus would be useful in evaluating radiant exposure-effect experiments.

EQUIPMENTThe Monitoring Apparatus

A light framework was constructed which is mounted next to, and on the lamp side, of the shutter. This framework holds a 5" x 7" x 3/16" sheet of clear polished Pyrex glass at an angle of about 57° to the optic axis, which glass is placed so that all the radiant energy in the beam must pass through it before striking the subject. At each air-glass interface approximately 4% of the radiant energy is reflected to one side where it forms an image of the positive carbon crater which duplicates that at the secondary focus of the elliptical mirror of the searchlight. Figure 1 presents a diagram of the monitor and figures 2, 3 and 4 are photographs of the instrument.

At the point of maximum reflected irradiance, a receiver was placed and calibrated to read directly in irradiance falling on the subject. The receiver consists of a 2" hollow copper integrating sphere with a circular aperture of approximately one square centimeter. A vacuum phototube photometer views the side wall of this integrating sphere. The voltage drop across a precision resistor placed in the cathode lead of the tube is fed to a Sanborn Model 128-T amplifier recorder assembly.

The monitor was calibrated by comparing its response to the irradiance at the exposure plane as measured by a standard radiation calorimeter. The absorption and reflection losses at the Pyrex plate are about 20%, reducing the value of maximum irradiance at the exposure plane to approximately 30 cal/cm²/sec.

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Figure 1

Diagram of Monitor

- 1) Incident Beam
- 2) Pyrex Plate
- 3) Transmitted Beam
- 4) Reflected Beam
- 5) Integrating Sphere
- 6) Vacuum Phototube
- 7) Shutter
- 8) Exposure Plane
- 9) Second Focal Point

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Figure 2
Photograph of Monitor

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Figure 3

Monitor in Position

- 1) Monitor Framework
- 2) Pyrex Plate
- 3) Integrating Sphere
- 4) Vacuum Phototube Mounting Box and Precision Load Resistor
- 5) Battery Supply Input and Signal Output Socket
- 6) Sliding Shutter (Open Position)

Figure 4

View of Monitor and Shutter from Rear of Searchlight Drum

- 1) Monitor Framework
- 2) Pyrex Plate
- 3) Integrating Sphere
- 4) Sliding Shutter (Open Position)
- 5) Position Carbon (Showing Positive Carbon Crater) and Positive Nose Cap
- 6) Negative Carbon
- 7) "Wing-tip" Nozzle for Mirror-Protecting Air Stream

METHODS

Design

Chester White pigs, weighing between 9.8 and 16.6 Kg, anesthetized by the intraperitoneal route with Dial in Urea-urethane (Ciba) (2), 70 mg/kg body weight, were used. In preparation for burning, the skin was closely clipped and gently sponged with a damp cloth.

In the first group (A), 24 exposures at each of nine diaphragm settings were given with the monitoring apparatus in place. Exposures were systematically randomized so that each combination occurred three times on one animal and at least one time in each of three rows on the sides of the animal. In order to fill in the data of group A, a second group of animals was burned.

In this group (B), 24 exposures were given at each of four diaphragm settings with the monitor. Exposures were systematically randomized so that each combination occurred once in each of three rows on each side of the animal.

With both groups the exposure time was 0.5 sec.

Evaluation

The lesions were evaluated 24 hours after burning and graded by the classification previously described (4, 5). A tabular summary of these criteria follows:

Laboratory Grade	Surface Appearance	Descriptive Term
1+	Erythema	Red Burn
2+	Patchy Coagulation	Spotted White Burn
3+	Uniform Coagulation	White Burn
4+	Steam Bleb	Blebbled White Burn

Methods Used in Analysis of Results

The irradiance value can be determined in two ways: (method 1) by the monitor response as calibrated against the standard radiation calorimeter, and (method 2) by predetermined calibration curves of the optical bench setting of the movable diaphragms, using the same standard radiation calorimeter. In the described experiment the dosage required for identical burns was determined in both these ways.

The most suitable technique of evaluation of radiant exposure-effect relationships has been by the method of Litchfield and Wilcoxon (3). It is this technique which is used in the comparison of the two methods of determining the irradiance.

RESULTS

Analysis of Results using the Response of the Monitoring Apparatus; Method 1.

The irradiance values were grouped into 14 intervals equally spaced on a logarithmic scale starting at 4.0 cal/cm²/sec. The size of the interval was chosen to put an adequate number of burns in each one. The average of the irradiance values within each interval was determined, and the number and percentage of lesions of each grade were tabulated. The burns obtained for these values are shown in table 1. From these data the 50% effective exposures and 0.95 confidence intervals were estimated. These are shown in table 3 under method 1.

Analysis of Results using Predetermined Calibration Curves; Method 2

Burns were produced at each of 13 diaphragm settings. From the calibration curve, the irradiance at each of these settings was obtained. The number and percentage of lesions of each grade for each irradiance are shown in table 2. Again, the 50% effective exposures and 0.95 confidence intervals

were estimated and shown in table 3, under method 2.

Table 3

Laboratory Grade	Method 1. 50% Effective Exposure (0.95 Confidence Interval) (cal/cm ²)	Method 2. 50% Effective Exposure (0.95 Confidence Interval) (cal/cm ²)
1+	2.7 (2.3 - 3.2)	2.9 (2.7 - 3.2)
2+	4.2 (3.7 - 4.7)	4.0 (3.8 - 4.2)
3+	5.4 (5.1 - 5.8)	5.5 (4.6 - 6.6)
4+	10.8 (9.4 - 12.5)	10.6 (9.8 - 11.5)

From table 3, it is seen that the estimates of the 50% effective exposures by either method differ at most only 0.2 cal/cm². The 0.95 confidence intervals overlap in all instances. There is, therefore, no significant difference in these two methods of treating the data: the one measuring the irradiance simultaneously with the exposure, the other ignoring this recorded exposure and using the predetermined value of irradiance from the calibration curve of the diaphragm settings.

Therefore, knowledge of simultaneously determined irradiance does not add valuable information in the estimation of the 50% effective exposures.

CONCLUSIONS

Although the use of a monitoring apparatus is of benefit in reducing the uncertainty in irradiance value in the production of a single burn, it is not of any practical value in the evaluation of radiant exposure-effect experiments using the carbon arc source. Its use has the disadvantage of reducing the irradiance from 37.5 to 30 cal/cm²/sec. Its one advantage in detecting malfunction of the carbon arc source is somewhat offset by the possibility of human error in the tedious reading of the monitor records.

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Table 1

RESULTS OF EVALUATION OF SURFACE APPEARANCE

Irradiance Interval (cal/cm ² /sec)	Total No. of Burns	Interval Average (cal/cm ² /sec)	Radiant Exposure (cal/cm ²)	No Burn 0	Erythema 1+	Patchy Coagula- tion 2+	Total Coagula- tion 3+	Steam Bleb 4+	Carboni- zation 5+
4.00- 4.68	21	4.49	2.3	21 (100%)					
4.69- 5.48	3	4.75	2.4	2 (67%)	1 (33%)				
5.49- 6.39	8	6.22	3.1	2 (25%)	6 (75%)				
6.40- 7.47	29	6.89	3.5	1 (3%)	23 (79%)	4 (14%)	1 (3%)		
7.48- 8.72	37	8.08	4.0	1 (3%)	14 (38%)	21 (57%)	1 (3%)		
8.73-10.2	37	9.46	4.7		7 (19%)	30 (81%)			
10.3-11.8	29	10.9	5.5		1 (3%)	12 (41%)	16 (55%)		
11.9-13.9	21	12.9	6.5				21 (100%)		
14.0-16.3	33	15.2	7.6			1 (3%)	31 (94%)	1 (3%)	
16.4-19.0	35	17.4	8.7			1 (3%)	32 (91%)	2 (6%)	
19.1-22.2	25	20.8	10.4				15 (60%)	9 (36%)	1 (4%)
22.3-26.0	10	23.2	11.6				1 (10%)	8 (80%)	1 (10%)
26.1-30.3	15	28.2	14.1				2 (13%)	12 (80%)	1 (7%)
>30.4	5	31.2	15.6					5 (100%)	

This table shows the number and percentages of burns for each irradiance interval as determined by Method 1, using the monitor response, produced by the carbon arc source modified by the Pyrex glass of the monitoring apparatus. (Exposure Time: 0.5 sec.)

Table 2

RESULTS OF EVALUATION OF SURFACE APPEARANCE

Group	Average Irradiance (cal/cm ² /sec)	Total No. of Exposures	Average Radiant Exposure (cal/cm ²)	No Burn 0	Erythema 1+	Patchy Coagulation 2+	Total Coagulation 3+	Steam Bleb 4+	Carbonization 5+
B	4.5	24	2.3	23 (96%)	1 (4%)				
B	6.5	24	3.3	2 (8%)	22 (92%)				
A	7.6	24	3.8	2 (8%)	14 (58%)	8 (33%)			
A	8.1	23	4.1		9 (39%)	13 (56%)	1 (4.5%)		
A	8.9	24	4.5		4 (17%)	19 (79%)	1 (4%)		
A	10.1	23	5.1		2 (9%)	19 (83%)	2 (9%)		
B	11.0	24	5.5			9 (37%)	15 (63%)		
B	12.8	24	6.4			1 (4%)	23 (92%)		
A	15.2	25	7.6			1 (4%)	24 (96%)		
A	16.5	24	8.3			1 (4%)	21 (87%)	2 (8%)	
A	18.4	25	9.2				21 (84%)	4 (16%)	
A	21.6	24	10.8				10 (43%)	13 (52%)	1 (4%)
A	28.3	22	14.2				2 (9%)	16 (73%)	4 (18%)

This table shows the number and percentage of burns for each average irradiance value as determined by Method 2 of using calibration curves, produced by the carbon arc source modified by the Pyrex glass of the monitoring apparatus. (Exposure Time: 0.5 sec.)

BIBLIOGRAPHY

1. Davis, T. P., Krolak, L. J. and Blakney, R. M., Studies of Flash Burns: The Carbon Arc Source, Univ. of Roch. Atomic Energy Project Report, UR-226, (1952).
2. Kingsley, H. D., Hogg, L. Jr., Payne, J. T. and Morton, J. H., Studies in Prolonged Anesthesia in Swine and Dogs, Univ. of Roch. Atomic Energy Project Report, UR-152, 65, (1951).
3. Litchfield, J. T. Jr. and Wilcoxon, F., A Simplified Method of Evaluating Dose-Effect Experiments, J. Pharm. and Thera., 96:99, (1949).
4. Morton, J. H., Kingsley, H. D. and Pearse, H. E., Studies on Flash Burns: Threshold Burns, Surg., Gyn. and Obs., 94:317, (1952).
5. Perkins, J. B., Pearse, H. E. and Kingsley, H. D., Studies on Flash Burns: The Relation of the Time and Intensity of Applied Thermal Energy to the Severity of Burns, Univ. of Roch. Atomic Energy Project Report, UR-217, (1953).