UR-494

STUDIES ON LARGE AREA SUB-FABRIC BURNS

by

K. M. Berkley
H. E. Pearse

THE UNIVERSITY OF ROCHESTER
ATOMIC ENERGY PROJECT
ROCHESTER, NEW YORK

LEGAL NOTICE

This report was prepared as an account of Government sponsored work. Neither the United States, nor the Commission, nor any person acting on behalf of the Commission:

- A. Makes any warranty or representation, express, or implied, with respect to the accuracy, completeness, or usefulness of the information contained in this report, or that the use of any information, apparatus, method, or process disclosed in this report may not infringe privately owned rights; or
- B. Assumes any liabilities with respect to the use of, or for damages resulting from the use of any information, apparatus, method, or process disclosed in this report.

As used in the above, "person acting on behalf of the Commission" includes any employee or contractor of the Commission to the extent that such employee or contractor prepares, handles or distributes, or provides access to, any information pursuant to his employment or contract with the Commission.

Price 75 cents. Available from the Office of
Technical Services, Department of Commerce
Washington 25, D. C.

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-494

Health and Safety

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.

STUDIES ON LARGE AREA SUB-FABRIC BURNS

by

K. M. Berkley
H. E. Pearse

Division: Special Programs

Division Head: H. A. Blair

Section: Flash Burns

Section Head: J. R. Hinshaw

Date Completed: 7/5/57

Date of Issue: 8/14/57

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

STUDIES ON LARGE AREA SUB-FABRIC BURNS

By

K. M. Berkley
H. E. Pearse

ABSTRACT

This study was made to determine the protective effect of fabrics on large area flash burns and the factors which modify them, using the same fabrics which had previously been investigated with the carbon arc source.

The effect of separating green (shade 116) and khaki No. I poplin, weighing 5.4 oz/yd^2 , and with reflectances of 0.20 and 0.35, respectively, was determined. The severity of burns was evaluated by both gross and microscopic appearance.

Both khaki and green poplin protect the skin from large area burns produced by 150 grams of magnesium flash powder fired at a distance of 25 cm. Khaki fabric is no more effective in giving protection than the green fabric, when the fabrics are in contact with or separated by 5 mm. from skin. However, with a 10 mm. air space, khaki fabric protects skin more than does the green fabric. By increasing the air space between the fabric and skin, the severity of burns is significantly reduced.

INTRODUCTION

Clinical observations of the protective effects of fabrics on human burns resulting from atomic explosions in Japan were that: 1) light colored fabrics gave more protection than darker ones, and 2) in areas where clothing was drawn tightly to the body, the burns were most severe.

The first studies on the protective effect of fabrics to radiant energy of high intensity and short duration were made in this laboratory (7, 8), using a 24 inch carbon arc searchlight modified by an ellipsoidal mirror. This source produces a burn of only 1.7 cm. in diameter and its depth of focus is only 1 to 2 cm. Both the small size of the burn and the shallow depth of focus limited the usefulness of this otherwise very versatile and controllable source for sub-fabric burn studies. A source was then developed to expose large areas by igniting a standard mixture of finely powdered magnesium, aluminum, and an oxidizing agent (10).

Bales et al. (1) using this magnesium source, studied large pieces of 8-1/2 oz. sateen, standard poncho, 5 oz. cotton khaki poplin and cotton tubing, which were spaced 5 cm. from the animal and 10 cm. from the source.

Mixter et al. using the carbon arc source found that as reflectance increased, more energy was required to produce the same grade of burn when judged by surface appearance (7).

Berkley, using similar methods to those of Mixter et al. found that the radiant exposure in cal/cm² required to produce superficial sub-fabric burns increased linearly by the amount of separation expressed in millimeters times a constant, which varies with the fabric studied (3, 4).

It seemed desirable to study the effect of fabrics, which has previously been investigated with a small area source (4), by means of the magnesium source. At the same time the factors of reflectance and separation could be assayed.

METHODS

Physical

The source of radiant energy was 150 gm. of magnesium flash powder, ignited as described by Roth et al. (10). This charge at a distance of 25 cm. provides an estimated incident energy of $16 \text{ cal/cm}^2/\text{sec.}$ over a 0.7 sec. exposure time.

The animal was placed in a shielded container exposing the skin through a three inch circular port placed 25 cm. from the source. The cloth when separated from the skin was tightly drawn over a 6 x 6 inch frame. After the explosion any flame was extinguished as quickly as possible usually within one to two seconds. The experimental setup is shown in Figure I.

Biological

Young Chester White pigs were anesthetized with Dial-urethane (Ciba) in dosage of 60 mgm/Kg. by intraperitoneal injection. The hair was closely clipped and the skin sponged gently with detergent and water.

Materials

The fabrics tested were green (shade 116) and khaki No. I poplin weighing 5.4 oz/yd^2 with measured reflectance of 0.20 and 0.35 respectively.

4

Fig. I

Preliminary Investigation

Since the utilization of a large piece of fabric in relationship to the size of the burn produced probably increases the severity of the burn by an increase in the energy of the exothermic reaction when the cloth ignites, it was felt desirable to minimize this. To reduce flaming as a factor a combination of distance of source from fabric and size of charge, which would produce a burn behind fabric but not ignite the fabric, was investigated. This was not entirely possible in the testing of 5-1/2 oz. cotton poplin, but 150 gm. of powder at a distance of 25 cm. from fabric in contact with skin would not ignite the fabric all the time and would produce a burn. If flaming occurred, it could be rapidly extinguished or the cloth removed within a matter of seconds, simulating human experience.

Experimental Design

The effects of each of the two fabrics separated 0, 5, and 10 mm. from the skin were studied and compared with the burn on bare skin. Seven burns were produced on each animal. The position and side, on which four burns would be produced, were determined by systematic randomization.

Evaluation

The burns were assessed 24 hours after burning by the following criteria (9):

- 0 - No burn
- 1+ - Erythema
- 2+ - Patchy whiteness
- 3+ - Uniform whiteness
- 4+ - Steam bleb

The percentage of any grade of burn was estimated by increments of 25%. A scoring system was devised considering only the most severe burn and disregarding any area of lesser severity, as follows:

<u>Grade</u>	<u>Percentage</u>	<u>Score</u>
1+	25	1
	50	2
	75	3
	100	4
2+	25	5
	50	6
	75	7
	100	8
3+	25	9
	50	10
	75	11
	100	12
4+	100	16

A biopsy of the most severe area was taken and fixed in 10% Formalin. Sections were stained by: 1) the standard hematoxylin and eosin, and 2) Verhoeff's technique as modified by Hinshaw and Pearse (6). Criteria for damage as determined histologically have been described previously (2, 5, 9). The depth of damage in the dermis was measured with the aid of an ocular micrometer scale marked 65 units to the millimeter. The results are tabulated in tenths of a millimeter.

A scoring system, which considered only the depth of damage was used in summarizing the results, were 0 - 0.1 mm. was scored 1; 0.1 - 0.2, 2; 0.2 - 0.3, 3, etc.

RESULTS

Observations

The green fabric when in contact with skin would always flame slowly; when separated 5 and 10 mm. from skin, it would flame rapidly to disintegration. The khaki fabric, when in contact, would likewise slowly flame in the majority of exposures; and, when separated 5 and 10 mm. from skin, it would always flame. However, flaming of the khaki fabric frequently began peripherally rather than centrally as was observed with the green fabric. The khaki maintained its integrity, if the flame was extinguished rapidly.

This difference in the physical reaction of the two fabrics was felt to be due to the green fabric absorbing more energy than did the khaki fabric, the latter of which had the greater reflectance.

Evaluation by surface appearance

Tables 1 and 2 show the grade and percent of total area burned resulting from the magnesium explosion for each amount of separation specified for green and khaki respectively. In the last column is shown the score which was given to the burn and the total of the scores for each air space studied. Table 3 and Figure II summarize the data.

Clothing when in contact with skin reduced the severity of burns from an average of 4+ in bare skin to 3+. On the whole, as the amount of separation of the fabrics from the skin increased, the severity decreased. However, an exception was noted in the case of the green fabric. The green poplin when separated 5 mm. from the skin gave more protection than when in contact with skin. But with increasing the amount of separation from 5 to 10 mm., no further increase in "protectivity" was noted.

Table 1.

Fabric	Space mm	Grade (Surface Appearance)				Score
		1+	2+	3+	4+	
Green (116)	0		50%	50%		10
				100%		12
				100%		12
				100%		12
				100%		12
				100%		12
				100%		<u>12</u>
					Total	70
Green (116)	5		100%			8
		50%	50%			6
			25%	75%		11
			25%	75%		11
			100%			8
			25%	75%		<u>11</u>
					Total	58 55
Green (116)	10		100%			8
			100%			8
				100%		12
				100%		12
		50%		50%		10
			50%	50%		<u>10</u>
					Total	48 60

This table shows the grade and percent of total area burned resulting from exploding 150 gms. of magnesium at a distance of 25 cm. from the pig, with green poplin (shade 116) interposed at the specified distance.

Table 2

Fabric	Space mm	Grade (Surface Appearance)				Score
		1+	2+	3+	4+	
Khaki No. I	0			100%		12
				100%		12
				100%		12
			50%	50%		10
				100%		12
				100%		12
					Total	70
Khaki No. I	5		100%			8
		25%		75%		11
			25%	75%		11
			100%			8
			100%			8
			100%	100%		12 8
					Total	56 58
Khaki No. I	10		75%	25%		9
		50%	25%	25%		9
		50%	50%			6
			100%			8
			100%			8
			100%			8
					Total	60 48

This table shows the grade and percent of total area burned resulting from exploding 150 gms. of magnesium at a distance of 25 cm. from the pig, with khaki No. I poplin interposed at a specified distance.

THE EFFECT OF SEPARATION OF $5\frac{1}{2}$ oz./yd.² COTTON POPLIN ON SEVERITY OF CUTANEOUS BURNS IN SWINE PRODUCED BY EXPLODING MAGNESIUM POWDER

Fig. II

No difference was noted in the severity of burns, judged by surface appearance, and produced when either the green or khaki fabric was in contact with skin or when either were separated 5 mm. from the skin. But when the fabrics were separated 10 mm. from the skin, the severity of the sub-fabric burn was much less with the khaki as a shield. Khaki poplin, spaced 10 mm. from skin, reduced the grade of burn from 4+, as observed in unprotected skin, to 2+.

Evaluation by depth of damage determined microscopically

Tables 4 and 5 show the depth of damage, resulting from the flash explosion for the specified conditions and in histological sections, stained by Hinshaw's method and standard hematoxylin and eosin stain, respectively. Evaluation of the severity by use of either of the staining methods does not significantly influence the conclusions. Table 6 summarizes these findings.

There is a tendency for the depth of damage to decrease as the air space increases. There is little difference in the depth of damage of burns produced beneath either fabric for 0 mm. or 5 mm. separation from the skin. However, when the air space is 10 mm., the depth of damage produced beneath the khaki fabric is definitely less than produced beneath the green fabric. These findings are in agreement with those found when the burns were evaluated by surface appearance alone.

DISCUSSION

By these studies it was demonstrated that fabrics give an appreciable amount of protection to skin burned by a large area source as has been observed in the field with nuclear weapon sources and in the laboratory with small area sources.

Table 4

Fabric	Space mm.	Trans- epidermal	Depth of Damage						Score
			Dermal (mm)						
			0-0.1	0.1-0.2	0.2-0.3	0.3-0.4	0.4-0.5	0.5-0.6	
Green (116)	0 5 10	1	1 3 2	1 3 2	4 2 2	1	1	19 13 14	
Khaki No. I	0 5 10		4 4	1	3 1	3 1	1	21 13 9	
Bare						2	1	1	19 x 6/4 = 28

This table shows the depth of damage of burns produced under the conditions specified, with sections stained by Hinshaw's method.

Table 5

Fabric	Space mm.	Trans- epidermal	Depth of Damage						Score
			Dermal (mm)						
			0-0.1	0.1-0.2	0.2-0.3	0.3-0.4	0.4-0.5	0.5-0.6	
Green	0			3	2		1		17
(116)	5		2	2	2				12
	10	1	1		3	1			14
Khaki	0				5	1			19
	5		4		2				10
No. I	10		5		1				8
Bare						2	1	1	19 x 6/4 = 28

This table shows the depth of damage of burns produced under the conditions specified, with sections stained by hematoxylin and eosin.

Table 3

Fabric	Separation		
	0 mm..	5 mm.	10 mm.
Green (116)	70	56	60
Khaki No. I	70	58	48
Bare Skin	96 (4 exposures with score of 64 corrected for 6 exposures)		

This table shows the total score for burns (6 exposures each) produced under the specified conditions and graded by surface appearance.

Table 6

Fabric	Separation		
	0 mm.	5 mm.	10 mm.
Green (116)	19 (17)	13 (12)	14 (14)
Khaki No. I	21 (19)	13 (10)	9 (8)
Bare Skin	28 (4 exposures with score of 19 corrected for 6 exposures)		

This table shows the total score for burns (six exposures each) graded by depth of damage. The figures, with and without parentheses designate H. & E. and Hinshaw's staining methods, respectively.

It was noted that there was a linear decrease in the severity of burns produced beneath khaki poplin as the space between the fabric and skin increased. This was noted using the small area source and the same fabric (4).

However, with the green poplin fabric there was a decrease in the severity of burns as the air space increased from 0 to 5 mm., but no appreciable change as the space rose from 5 to 10 mm. This finding is different from those found with the small area source used for making superficial burns. To explain this difference between behavior of the green and khaki fabric, a consideration was made of the possible effect of reflectance and flaming.

It was observed that the green poplin disintegrated when it was separated either 5 or 10 mm. from the skin, whereas, the khaki fabric remained relatively intact. The disintegration of the green fabric as contrasted to the relative intactness of the khaki cloth is probably a result of the difference in quantity of the energy absorbed, less energy being reflected by the green fabric.

It was also noted, with the fabrics spaced 10 mm. from the skin, that the khaki fabric reduced the severity of the bare skin burns to a greater extent than the green poplin did. This is probably due to reflectance. Apparently reflectance was not a significant factor until 10 mm. of separation existed under the conditions of this experiment.

CONCLUSIONS

1. Both khaki and green (shade 116) poplin, 5 oz/yd², protect the skin from large area burns produced by a magnesium flash powder source fired at 25 cm.
2. Khaki fabric is no more effective in giving protection than the green fabric, when the fabrics are in contact with or separated by 5 mm. from skin. However, with a 10 mm. air space, khaki fabric protects skin more than does the green fabric.
3. With an air space between the fabric and skin, the severity of burns is significantly less than that observed with the fabric in contact with skin.

BIBLIOGRAPHY

1. Bales, H. W., Roth, R. E., and Pearse, H. E., Studies of Flash Burns: The Screening Effect of Fabric at a Distance from Animals, Univ. of Roch. Atomic Energy Project Report, UR-422, (1956).
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. Berkley, K. M., The Effect of Air Space on Sub-Fabric Burns in Swine, Univ. of Roch. Atomic Energy Project Report, UR-490, (1957).
4. Berkley, K. M., Small Area Sub-Fabric Flash Burns: The Effects of Fabric Reflectance, Air Space, Fabric Combinations with Air Space, Fire Retardant Treatment of Fabrics, and Exposure Time, Univ. of Roch. Atomic Energy Project Report, UR-493, (1957).
5. Hinshaw, J. R., Bales, H. W., and Pearse, H. E., The Relationship Between Surface Grade and Depth of Damage of Burns Produced by Radiant Thermal Energy, Univ. of Roch. Atomic Energy Project Report, UR-440, (1956).
6. Hinshaw, J. R., and Pearse, H. E., Histologic Techniques for the Differential Staining of Burned and Normal Tissues, Gyn., Obs., and Surg., 103: 726-730, (1956).
7. Mixter, G., Jr., Davis, T. P., and Pearse, H. E., The Sub-Fabric Weight and Exposure Time, Univ. of Roch. Atomic Energy Project Report, UR-386, (1955).
8. Morton, J. H., Kingsley, H. D., and Pearse, H. E., Studies on Flash Burns: The Protective Effect of Certain Fabrics, Surg., Gyn., and Obs., 94: 497-501, (1952).

BIBLIOGRAPHY (Continued)

9. 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).
10. Roth, R. E., Bales, H. W., and Pearse, H. E., A Method for the Safe Firing of Magnesium Powder to Produce Large Area Flash Burns, Univ. of Roch. Atomic Energy Project Report, UR-435, (1956).