MR 743

AUTHORS: Gersten JW, Wakim KG, Krusen FH:

DATE: 1950

TITLE: A method for decreasing reflection of microwaves by tissue.

SOURCE: Arch of Phys Med 31:281-286, 1950

MAIN SUBJECT HEADING:

AN	HU	AT	IH	M
ANALYTICS	HUMAN EFFECTS	ANIMAL TOXICITY	WORKPLACE PRACTICES-ENGINEERING CONTROLS	MISCELLANEOUS

SECONDARY SUBJECT HEADINGS: AN HU AT IH M

Physical/Chemical Properties

Review

Animal Toxicology

Non-occupational Human Exposure

Occupational Exposure

Epidemiology

Standards

Manufacturing

Uses

Reactions

Sampling/Analytical Methods

Reported Ambient Levels

Measured Methods

Work Practices

Engineering Controls

Biological Monitoring

Methods of Analysis

Treatment

Transportation/Handling/Storage/Labelling

MR-743

A METHOD FOR DECREASING REFLECTION OF MICROWAVES BY TISSUE *

JEROME W. GERSTEN, M.D.
Fellow in Physical Medicine, Mayo Foundation,

KHALIL G. WAKIM, M.D., Ph.D.
Section on Physiology, Mayo Clinic

and

FRANK H. KRUSEN, M.D.
Section on Physical Medicine, Mayo Clinic,

ROCHESTER, MINN.

That microwaves can heat tissues[1] has been shown conclusively. However, because of high reflection at the surface of the skin, the heating efficiency of these electromagnetic waves is low. To make the transfer of energy from air to tissues more efficient, an impedance matching device[2] may be placed on the surface of the skin. Not only would this increase the transfer of thermal energy to the tissues, but it might also make it possible to heat small areas selectively, with inappreciable elevation of temperature in adjacent tissues.

The dielectric mycalex[3] was tested in order to determine whether the anticipated decrease in reflection by impedance matching would be realized and thus result in more efficient heating of tissues.[4]

Methods

Sixty-nine observations were made on 9 normal men. Skin and muscle temperatures at a depth of 1.0 cm. were recorded by means of copper-constantan thermocouples. The source of the microwaves was an air-cooled multicavity magnetron, operating at a frequency of 2,450 megacycles per second. A hemispherical director, 9 cm. in diameter, radiated the energy to the skin. In all the observations the microwaves were directed to the volar surface of the forearm, and the distance from the director to the skin was 5 cm. For impedance matching a cylindrical block of mycalex with a dielectric constant of 8.0, a diameter of 5.08 cm. and a thickness of 10.32 mm. was placed on the skin in the microwave field.

In all but 3 of the observations, temperature readings were taken at two points, one of which was under the mycalex and the other 6 to 8 cm. away and not covered by the mycalex during irradiation. Both points were in the zone of maximal energy, as determined from the heating pattern of the director.

In group A (10 observations), both points were at first covered by the mycalex cylinder and the skin temperature was taken underneath the cylinder at intervals of one minute for five minutes. The mycalex was moved away from one point, and the tem-

* Read at the Twenty-Seventh Annual Session of the American Congress of Physical Medicine, Cincinnati, Sept. 7, 1949.

1. Krusen, F. H.; Herrick, J. F.; Leden, Ursula, and Wakim, K. G.: Microkymatotherapy: Preliminary Report of Experimental Studies of the Heating Effects of Microwaves ("Radar") in Living Tissues, Proc. Staff Meet., Mayo Clin. 22:209 (May 28) 1947. Leden, Ursula M.; Herrick, J. F.; Wakim, K. G., and Krusen, F. H.: Preliminary Studies on the Heating and Circulatory Effects of Micro-waves — "Radar," Brit. J. Phys. Med. 10:177 (Nov.-Dec.) 1947. Worden, R. E.; Herrick, J. F.; Wakim, K. G., and Krusen, F. H.: The Heating Effects of Microwaves With and Without Ischemia, Arch. Phys. Med. 29:751 (Dec.) 1948. Osborne, S. L., and Frederick, J. N.: Microwave Radiations: Heating of Human and Animal Tissues by Means of High Frequency Current With Wavelength of Twelve Centimeters (the Microtherm), J. A. M. A. 137:1036 (July 17) 1948. Siems, L. L.; Kosman, A. J., and Osborne, S. L.: A Comparative Study of Short Wave and Microwave Diathermy on Blood Flow: The Role of the Somatic and Sympathetic Nerves in the Vascular Response to Deep Tissue Heating, Arch. Phys. Med. 29:759 (Dec.) 1948. Gersten, J. W.; Wakim, K. G.; Herrick, J. F., and Krusen, F. H.: The Effect of Microwave Diathermy on the Peripheral Circulation and on Tissue Temperature in Man, ibid. 30:7 (Jan.) 1949. Rae, J. W., Jr.; Herrick, J. F.; Wakim, K. G., and Krusen, F. H.: A Comparative Study of the Temperatures Produced by Microwave and Short Wave Diathermy, ibid. 30:199 (April) 1949.

2. Bronwell, A. B., and Beam, R. E.: Theory and Application of Microwaves, ed. 1, New York, McGraw-Hill Book Company, Inc., 1947, pp. 265-292.

3. Produced by Mycalex Corporation of America, of Clifton, New Jersey, to whom we are grateful for prompt and generous supply of the material.

4. The proper design of an impedance matching device is dependent on fundamental measurements of dielectric constant and tangent loss. These measurements were made in prior studies by J. F. Herrick, D. G. Jelatis, and G. M. Lee, which will be published later.

perature of the skin at the two points was taken at minute intervals for an additional five minutes. The thermocouples were then removed from the skin, and the forearm was irradiated for one minute with microwaves at a plate current of 100 ma. (approximately 80 watts). The thermocouples were reapplied to the skin immediately after the period of irradiation was ended, and the temperatures were recorded at the end of exactly one minute.

In group B (20 observations) control temperatures of the muscle were taken at a depth of 1.0 cm. at two points. When the temperature became practically constant the needles were removed, one of the two points was covered with the mycalex cylinder, the other in the zone of maximal energy was left uncovered, and the area was irradiated with microwaves for one minute at a plate current of 100 ma. The temperature of the muscle at the two points was again recorded one minute after irradiation.

Group C (36 observations) was similar to group B, except that the duration of exposure to microwaves was varied to ten, fifteen or twenty minutes and the plate current was varied from 40 to 60, to 75 ma.

In group D (3 observations) temperature readings of the muscle at a depth of 1.0 cm. were taken at only one point, in the zone of maximal energy. When the temperature became practically constant, the area was irradiated for one minute at a plate current of 100 ma., without the use of the mycalex. Temperature readings were taken fifteen seconds and one minute after irradiation was stopped. When the muscle temperature had returned almost to the control level, the area was again irradiated for one minute with a plate current of 100 ma., but this time the point at which temperature was studied was covered with mycalex. Temperature readings were taken fifteen seconds and one minute after heating was ended. Finally, when the muscle temperature had returned to the control level, the area was heated a third time with a plate current of 100 ma. for one minute, without the mycalex. Temperature readings were taken fifteen seconds and one minute after the irradiation. As with the other groups, the microwave director was 5 cm. from the skin surface.

Results

Group A (tables 1 and 2). — After irradiation for one minute at a plate current of 100 ma., there was an average rise of skin temperature of 1.08 de-

TABLE 1. — *Rise of Skin Temperature in Degrees Centigrade After Irradiation for One Minute at 100 Ma. Plate Current.*

	Control Temperature Taken at One Minute Intervals Before Irradiation — Both Points Covered With Mycalex — 1 Min.	2 Min.	3 Min.	4 Min.	5 Min.	— Point B Not Covered With Mycalex — 1 Min.	2 Min.	3 Min.	4 Min.	5 Min.	Temperature After Irradiation, ° C.
Point A	33.9	34.0	34.0	34.1	34.1	34.2	34.2	34.2	34.2	34.2	36.55
Point B	33.8	33.9	33.9	33.9	34.0	34.1	34.2	34.3	34.4	34.4	35.48*

* Point B not covered by mycalex during irradiation.

TABLE 2. — *Comparison of Rise of Skin Temperature Produced by Exposure for One Minute at 100 Ma. Plate Current.*

	Mycalex	No Mycalex	Difference
Average rise in temperature	2.35° C.	1.08° C.	1.27° C.
Standard deviation	0.67° C.	0.44° C.	0.66° C.
Standard error	0.21° C.	0.14° C.	0.21° C.
t	....	....	6.04
p	....	....	<0.001

grees C. at the point not covered by the mycalex cylinder, with a range from 0.1 to 1.7 degrees. At the point covered by mycalex there was an average rise of skin temperature of 2.35 degrees, with a range from 1.1 to 3.4 degrees. The rise of skin temperature of the covered point was greater than that of the uncovered one in every instance, with an average difference of 1.27 degrees and a range from 0.2 to 2.3 degrees. The difference in the rise of temperature at the two points was significant (table 2).

Group B (table 3). — The average rise of muscle temperature after one minute of exposure to microwaves at a plate current of 100 ma. was 0.70

degree C. at the point not covered by mycalex, with a range from 0.4 to 1.0 degree. At the point covered by mycalex, the average rise of muscle temperature was 2.21 degrees, with a range from 0.9 to 3.2 degrees. The rise in temperature was greater at the point covered with mycalex than at the

TABLE 3. — *Comparison of Rise of Muscle Temperature Produced by Exposure for One Minute at 100 Ma.*

	Mycalex	No Mycalex	Difference
Average rise in temperature	2.21° C.	0.70° C.	1.51° C.
Standard deviation	0.66° C.	0.19° C.	0.71° C.
Standard error	0.15° C.	0.04° C.	0.16° C.
t		....	9.4
P		....	<0.001

uncovered one in every instance. The average difference was 1.51 degrees, with a range from 0.3 to 2.7 degrees.

Group C (table 4, charts 1 and 2). — When the intensity of irradiation was 40 ma. (approximately 32 watts), the average rise of muscle temperature at the point covered by mycalex was 3.2 degrees C. at the end of ten minutes, 3.0 degrees at the end of fifteen minutes and 5.0 degrees at the end of twenty minutes of irradiation. At the point not covered with mycalex the average temperature rise was 1.3 degrees at the end of ten minutes, 1.3 degrees at the end of fifteen minutes and 1.5 degrees at the end of twenty minutes.

TABLE 4. — *Rise in Temperature of Muscle After Exposure to Microwaves.*

Duration of Exposure, Min.	Plate Current, Ma.	Number of Studies	Temperature, °C. Mycalex	No Mycalex	Difference
	40	4	3.2	1.3	1.9
10	60	3	5.5	2.0	3.5
	75	5	6.4	2.8	3.6
	40	4	3.0	1.3	1.7
15	60	4	5.0	2.1	2.9
	75	4	5.1	3.5	1.6
	40	4	5.0	1.5	3.5
20	60	4	5.5	2.5	3.0
	75	4	5.2	3.8	1.4

When the plate current was 60 ma. (approximately 48 watts), the average rise of muscle temperature at the covered point was 5.5 degrees C. after ten minutes of irradiation, 5.0 degrees after fifteen minutes and 5.5 degrees after twenty minutes. At the point not covered with mycalex, the average temperature rise was 2.0 degrees after ten minutes of irradiation, 2.1 degrees after fifteen minutes and 2.5 degrees after twenty minutes.

With a plate current of 75 ma. (approximately 60 watts) the average rise of muscle temperature at the point covered with mycalex was 6.4 degrees after ten minutes of irradiation, 5.1 degrees after fifteen minutes and 5.2 degrees after twenty minutes. At the point not covered by mycalex the average temperature rise was 2.8 degrees after ten minutes of irradiation, 3.5 degrees after fifteen minutes and 3.8 degrees after twenty minutes.

Group D (chart 3). — When mycalex was not used, the average rise of muscle temperature was 0.9 degrees C. fifteen seconds and 0.7 degree one minute after exposure for one minute at 100 ma. With the mycalex cylindrical block in the irradiated area, the average rise in temperature was 2.5 degrees fifteen seconds and 2.0 degrees one minute after irradiation. When the mycalex was removed and heating repeated for one minute at 100 ma.,

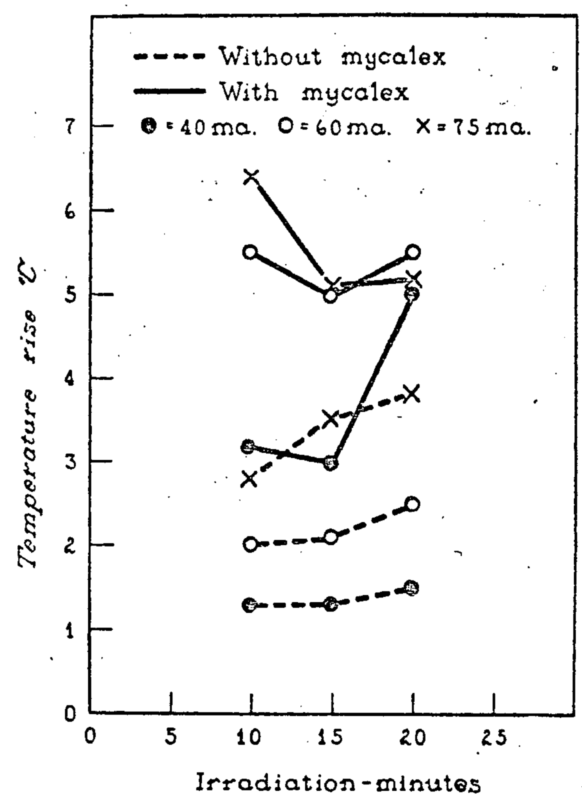

Chart 1. — Rise in temperature of muscle (depth of 1.0 cm.) after exposure to microwaves for periods of ten, fifteen and twenty minutes and with current intensities of 40, 60 and 75 ma. The solid line indicates the temperature change at the point covered by mycalex, and the broken line indicates the temperature change at the point not covered by mycalex.

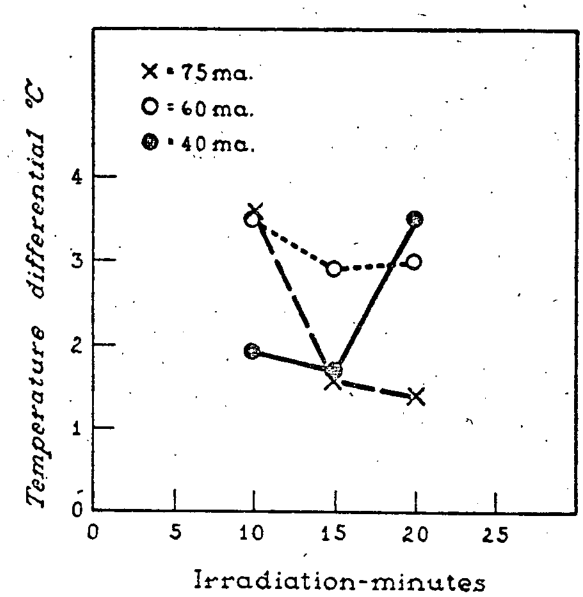

Chart 2. — Difference in temperature between point covered by mycalex and the one not covered by mycalex after exposure to microwaves for periods of ten, fifteen and twenty minutes and with current intensities of 40, 60 and 75 ma.

the average rise in temperature was 0.8 degree fifteen seconds and 0.7 degree one minute after heating was stopped.

A few experiments were performed in order to determine the change in temperature of the mycalex cylinder when it was exposed to the microwave field. When the cylinder was placed at a distance of 4 cm. from the director, the maximal recorded rise in temperature, either on the surface or in the substance of the cylinder, was 0.1 degree C. after one minute of irradiation at a plate current of 100 ma.

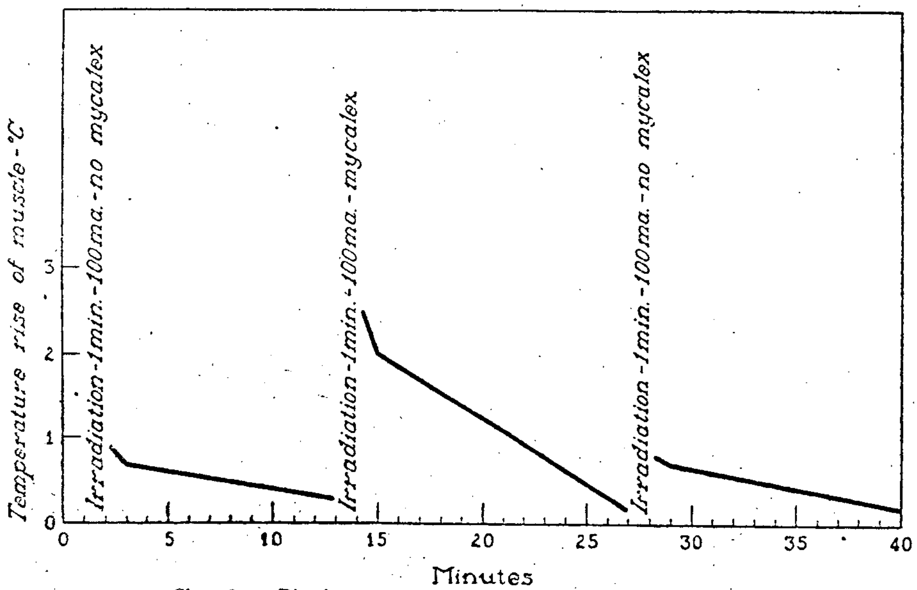

Chart 3. — Rise in temperature of muscle at a depth of 1.0 cm. after three consecutive periods of exposure to microwaves for one minute with a current intensity of 100 ma. During the first and third periods the mycalex was not used, while during the second period the mycalex was placed over the point studied. The rise in temperature was significantly greater after irradiation when the mycalex was placed on the skin surface than when it was not present.

Comment

The interposition of the mycalex cylinder between the director and the skin decreases the amount of reflection of the electromagnetic waves by the skin. As a result, significantly higher temperatures are recorded in the region covered by the dielectric than in the uncovered regions. The dielectric constant of the mycalex used in this study was 8.0. This constant may not be the ideal one, and material with a different dielectric constant may result in even higher transmission of energy from air to the tissues.

The studies on group C were performed in order to determine the optimal combination of duration and intensity of irradiation for the production of high rises of temperature under the mycalex cylinder (5 to 6 degrees), with relatively little heating outside the cylinder. This procedure may be of importance in heating tissues adjacent to regions which should not have appreciable rises of temperature. Chart 2 showed that the greatest difference in temperature between matched and unmatched areas for the longest period of time occurs when the plate current is 60 ma. The differences in rises in temperature at this current intensity were 3.5, 2.9 and 3.0 degrees C. at the durations used — namely, ten, fifteen and twenty minutes. With a smaller plate current (40 ma.), the temperature differential between covered and uncovered points was slight at ten and fifteen minutes and did not increase until twenty minutes of irradiation, when it became 3.5 degrees. On the other hand, when the current was greater (75 ma.), a temperature differential of 3.6 degrees was reached early during the course of heating, but was maintained for only a short period. It is likely that the circulation under the mycalex had increased sufficiently to bring cooling factors into play, while the tissues not covered by mycalex continued to accumulate heat.

Conclusions

From this study the following conclusions were drawn:

1. Impedance matching, by the placing of an appropriate dielectric between air and tissue, may be used to decrease the amount of microwave energy reflected by tissues.

2. By choice of certain combinations of current intensity and duration of irradiation, some areas may be heated satisfactorily while adjacent areas receive relatively little heat.

BEDS AND REHABILITATION

LEONARD J. YAMSHON, M.D.

Instructor in Physical Medicine and Rehabilitation, College of Medical Evangelists;
Attending Physiatrist, Birmingham Veterans Administration Hospital

LOS ANGELES

One of the major obstacles encountered by the patient during rehabilitation and convalescence is the hospital bed. Early ambulation is now an accepted procedure following surgery and childbirth. Walking is necessary in the convalescent phase of all medical conditions. In chronic rehabilitation conditions, ambulation is an essential activity. It is one of the important accomplishments in the activities of daily living. Even those patients who confine themselves to a wheel chair find it necessary to get out of bed and bear weight on their feet, even though this time of weight bearing is brief.

The standard hospital bed is 36 inches from the top of the mattress to the floor. These beds were designed to accommodate handling of the patient by the nurse while nursing care remains necessary. Unfortunately, no consideration was given to the fact that a patient might ultimately be encouraged to get out of bed, to sit in a chair or wheel chair or walk.

In the existing circumstances, the patient is faced with the following possibilities: 1. Jumping from the sitting position on the bed to the floor. While most patients would not attempt this method, an occasional patient who considers himself athletically inclined will, in moments of bravado, jump. The end result may be strains, sprains or, occasionally, falls and fractures. 2. Sliding from the bed to the floor. The patient may use one of two methods: (*a*) sitting on the edge of the bed and gradually lowering himself until his feet touch the floor; this is difficult for weakened muscles and often is the cause of strains; (*b*) from the prone position, first sliding one leg over the edge of the bed and then sliding the other leg. 3. Stepping onto a footstool and then to the floor. A potential danger remains because the stool may slip or tilt. Furthermore, a gap of several inches is usually present between