

THE INHIBITION OF SWEATING IN MAN BY SCOPOLAMINE *

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It has been recognized for many years that the control of body temperature during general anesthesia is altered considerably. Earlier workers recognized hypothermia associated with the administration of ether by open methods. This was considered an important factor in the precipitation of shock during the anesthetic and surgical experience (1). In more recent years, particularly with the almost routine employment of closed circuits with carbon dioxide absorption methods, observations of elevated body temperature during general anesthesia have been made with increasing frequency. In fact, in certain circumstances, excessive hyperthermia with an associated high mortality has been a problem of serious clinical importance (2).

It is generally conceded that general anesthesia usually reduces total oxygen consumption and diminishes heat production (3). A profitable first approach to the understanding of the problem of heat regulation during anesthesia appeared to be an examination of elements which might account for diminished heat loss. It must be recognized that a study of this kind presents many complexities. Accordingly, a single objective was sought, that of determining the effect of the inhibition of the sweating mechanism.

The study was planned so that the radiative, conductive and convective losses were minimized and heat was dissipated primarily through evaporation. Scopolamine hydrobromide was given to unanesthetized man subjected to the stress of environmental temperatures approximately equal to the normal average skin temperature. This drug, commonly employed in preanesthetic medication, is a cholinergic blocking compound and prevents the activation of the sweat glands which are innervated by cholinergic nerves.

METHODS

The 7 subjects were, with a single exception, healthy, volunteer, white men between the ages of 25 and 40 years who had usually fasted

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for approximately fourteen hours. Occasionally, a light carbohydrate meal was ingested shortly before the study period. The subjects remained recumbent and at rest except during measurements and wore only loose, light, cotton shorts. Water by mouth was permitted freely. Appropriate corrections for water intake were made in the measurement of weight loss which is described below. The subject, G. N., was unable to sweat normally because of extensive skin burns which had been treated by skin grafts. The grafted areas were well healed.

The rectal temperature was measured with a conventional clinical mercury thermometer inserted to a depth of 6 cm. and left in place for five minutes. Brachial arterial pressure and heart rate were also measured by simple clinical means. Weight measurements were made in duplicate on a sensitive beam balance until agreement within 20 Gm. was achieved between two successive readings.

The weight loss, corrected for water intake, was considered to be composed of: (a) evaporation from the skin through gross sweating and insensible perspiration; (b) evaporation from the lungs as expired water vapor; (c) sweat lost from the skin without evaporation, that is, rolling off or being absorbed by sheets, clothing, and so forth, and (d) the net loss due to the utilization of oxygen and the excretion of carbon dioxide during respiration.

The difference between the oxygen utilized and the carbon dioxide exhaled depends upon the metabolic patterns as reflected in the respiratory quotient. The net exchange of gases, however, rarely exceeds 10 Gm. per hour which is within the experimental error in weighing.

The experiments were performed in four-hour periods in an insulated room where the temperature and relative humidity were stabilized between 95 and 97 F. and 50 and 60 per cent, respectively. Occasionally, the room temperature exceeded the maximum by as much as 4 F. and declined below the minimum by 2 F. for short periods of time. A steady movement of air was maintained by a blower system. Steam was added in the blower system outside of the room to keep the temperature and humidity constant. Room temperature and humidity were determined frequently with a sling psychrometer.

The changes in weight and rectal temperature under the conditions described when subjects received no drug were compared with changes occurring when scopolamine hydrobromide was given. Accordingly, each subject was observed in the heated room without medication for a period of four hours. One week later the same subject was exposed to the same environment fifteen minutes after the intramuscular administration of 0.4 mg. of scopolamine hydrobromide. Two of the subjects were exposed to this environment on a third occasion a week after the second study period. Scopolamine, 0.4 mg., was then given as described and repeated two hours later. One gram of weight loss as water was considered to provide for the loss of 0.6 Calories from the body (4).

The study was conducted between May and September 1950. The effect of acclimatization was minimized by completing the observations on any one individual within one week, except for those observations in the 2 subjects who received an additional dose of scopolamine. These latter observations were carried out over a period of two weeks.

The influence of the first exposure to heat upon sweating during the second exposure was no doubt real and in the direction of increasing sweating (5). Since the effect of scopolamine was to diminish sweating, the part played by this compound is all the more significant.

RESULTS

The normal individuals sweated profusely when scopolamine was not given. After the injection of 0.4 mg. of scopolamine, there was no visible sweat on the skin until two hours had elapsed when mild sensible sweating was observed. When a second dose of scopolamine was given after two hours, no sensible sweating appeared during the entire four-hour period. The changes in weight during various procedures are presented in table 1. The caloric value of the water lost is also given as a function of time and of surface area (Cal./sq.M./hr.).

When reference is made to table 1, it can be seen that weight lost through sweating was diminished when 0.4 mg. of scopolamine was given. A further inhibition followed the administration of 0.8 mg. of scopolamine.

The rectal temperature and blood pressure were not altered either in the control periods or when scopolamine was given. Slight tachycardia was noted following scopolamine.

COMMENT

The amount of sweat lost by normal men under such circumstances was decreased on the average in six experiments by 35 per cent when 0.4 mg. of scopolamine was given. A rise in rectal temperature was not noted, however, in any of the experiments. Apparently the impairment of sweating did not reduce the heat loss below the level of heat production.

The question, therefore, arises as to whether such an inhibition explains in part certain cases of hyperthermia during anesthesia preceded by premedication with scopolamine. A direct answer cannot be given since experimental hyperthermia has not been produced in anesthetized man. Certain conclusions can be drawn, however, which may be germane to the problem.

It can be said that hyperthermia would probably occur in a subject suffering serious suppression of sweat, as in the 2 subjects given 0.8 mg. of scopolamine, if heat could not be lost by other routes. In many operations heat loss is impaired by a high room temperature and

TABLE 1
THE EFFECT OF SCOPOLAMINE ON WEIGHT AND HEAT LOSS DURING CONDITIONS OF ACTIVE SWEATING

Subject		Surface Area, sq.M.	Control Period (4 hours)				0.4 mg. Scopolamine (4 hours)				0.8 mg. Scopolamine (4 hours)				
			Wt. Loss, Gm.	Caloric Equiv., Cal./M ² /hr.	Rectal Temp., °F. Before Heat Exposure	Maximum during Exposure	Wt. Loss, Gm.	Caloric Equiv., Cal./M ² /hr.	Rectal Temp., °F. Before Heat Exposure	Maximum during Exposure	Wt. Loss, Gm.	Caloric Equiv., Cal./M ² /hr.	Rectal Temp., °F. Before Heat Exposure	Maximum during Exposure	
1	V. L.	1.82	660	54	99.6	99.8	330	27	50	99.8	99.4				
2	A. H.	2.04	810	59	100.0	99.8	600	44	26	98.8	99.8				
3	H. H.	1.87	870	69	99.2	99.2	630	50	27	98.8	99.4				
4	J. K.	1.77	1020	86	99.4	99.2	780	69	35	99.0	99.2				
5	R. P.	1.93	990	76	99.0	99.4	600	46	39	98.8	98.8	390	30	61	98.0
6	R. S.	1.82	990	81	98.6	99.0	600	54	33	98.8	99.0	570	47	42	98.4
Average:				71				48	35						
Control															
7	G. N.	1.71	630	55	98.0	99.0	540	47	14	98.8	99.0				

humidity and by thick layers of drapes. The closed circuit respiration apparatus may be important because expired water vapor is then almost entirely rebreathed and cannot subserv a heat dissipating function. These disabilities may be accentuated by heat gain in the form of radiant heat from the powerful operating lights focused on the patients, which in the case of the infant or small child may cover the entire body. Radiant energy from operating personnel contributes to the heat load. Studies are in progress to define quantitatively the nature of the heat load from these various sources.

Under heat stress the normal subject sweats excessively; that is, some sweat is lost without evaporation, or is wiped off, and thus exerts no cooling action (5). A considerable decline in sweating, therefore, can occur without a decline in evaporative heat loss. This excess sweat probably constituted the bulk of the weight retained during the action of scopolamine. It is not unlikely that poorly hydrated patients, especially children who are subjected to long operations, are incapable of even a normal response to a heat load. The handicap of further inhibition of sweating by the scopolamine administered before operation could easily tip the scales in the direction of heat retention. Elevated room temperature above 85 F. becomes important in this regard because loss by radiation becomes less and less important and sweating more important as the temperature of the environment approaches that of the skin.

Further study of this and other aspects of temperature regulation during operations under anesthesia is needed. The pharmacologic aspect, although important, is only one part of the problem. The actual heat load imposed by drapes, a humid room, proximity of surgeons and lights should be quantitated. It is particularly important to evaluate the role of carbon dioxide absorption technics in inhalation anesthesia under conditions of high environmental temperatures. The respiratory route may constitute a leading role in dissipating heat in the "zone of evaporative cooling" when the sweating mechanism is suppressed. Consideration should be given to the influence of spinal, peridural and caudal anesthesia on heat loss by virtue of inhibition of sweating.

SUMMARY

Scopolamine was found to depress the rate of sweating in normal man by 35 per cent. It is considered that such inhibition may be a factor contributing to hyperthermia during surgical operations, especially if normal sweating is further impaired by illness or dehydration.

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REFERENCES

1. Waters, R. M.: Advantages and Technique of Carbon Dioxide Filtration with Inhalation Anesthesia, *Anesth. & Analg.* 5: 160-162, 1926.
2. Lundy, J. S.: Convulsions Associated with General Anesthesia, *Surgery* 1: 666-687 (May) 1937.
3. Guedel, A. E.: Inhalation Anesthesia, New York, The Macmillan Company, 1937, p. 63.
4. Hardy, J. L. in Newburgh, L. H.: Physiology of Heat Regulation and the Science of Clothing, Philadelphia, Saunders, 1949.
5. Robinson, S. in Newburgh, L. H.: Physiology of Heat Regulation and the Science of Clothing, Philadelphia, Saunders, 1949.

PROGRAM

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November 5-8, 1951

Monday, November 5, 1951

MORNING: Refresher Courses

AFTERNOON: Refresher Courses
Meeting of the Board of Directors*Tuesday, November 6, 1951*MORNING: First Session, House of Delegates
Official LuncheonAFTERNOON: General Session
Open Forum of Anesthesiological Subjects*Wednesday, November 7, 1951*

MORNING: Refresher Courses

AFTERNOON: Refresher Courses
Second Session, House of DelegatesEVENING: Cocktail Party and Dinner for Presentation
of Award to Doctor Frank Lahey*Thursday, November 8, 1951*MORNING: General Session
Official Luncheon

AFTERNOON: General Session