The Clinical Significance of DISTURBANCES IN THE DELIVERY OF SWEAT

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Part I is a description and discussion of SELECTED METHODS of assaying the quantity and other characteristics of sweat.

Brief descriptions are submitted of various available techniques and some of the fundamental principles in investigating both physiologic sweating and the disturbances of sweating.

Data obtained under physiologic conditions are presented.

(continued on front flap)

American Lecture Series®

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To Charles C. Harris and George M. MacKee
whose understanding and encouragement
made this work possible

Authors' Preface

In December 1949 and again in December 1950, the *Clinical Significance of Disturbances in Sweating* was discussed in some detail by the present authors before the American Academy of Dermatology. It was after hearing our second discussion in 1951, that Dr. Arthur Curtis suggested that we prepare a monograph on this topic for publication in *American Lectures in Dermatology*.

Although we gladly acceded to this suggestion, we knew that this field was one undergoing very great and widespread modern re-examination; and one in which not only we, but other investigators all over the world, were currently engaged in intensive and, in many instances, fundamental studies.

While these facts made the task of preparing a summarizing monograph all the more attractive to us, they also made it much more difficult. For just as we had anticipated, during the many months of preparation of this book new knowledge and new concepts were continually being added, both from numerous other investigators and from our own laboratories. Despite our best efforts at running revisions of the manuscript, there came a time—a deadline—when additions and alterations had to cease and the present text had to be frozen in the unforgiving, immutable forms of the printer's type. So while we have spared no trouble to make this monograph as up-to-date as possible, we realize that our efforts have not succeeded in keeping full pace with the tremendous rate of progress in this particular field.

We know that our fellow investigators will appreciate the technical problems involved in the preparation of this summary of so rapidly advancing and expanding a segment of medical science; and will understand why some of their latest results or ideas may not have received the full attention which they merit.

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New York, N. Y.
March 12, 1954

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The Clinical Significance of

DISTURBANCES IN THE DELIVERY OF SWEAT

PART I

Investigative Approaches

(*Some Methods of Assaying the Quantity and Other Characteristics of Sweat; Physiologic Data*)

THIS section of our monograph on sweating will be devoted to the description and discussion of selected methods and some of their results in assaying the delivery of sweat in man.

The present outline does not pretend to include a complete review of disturbances of sweating but will be confined to a discussion of certain features more or less related to our own investigations in this field. Therefore, those measures which we have actually employed in our studies will receive special emphasis. It is hoped that some of the results which we have obtained with these methods under *physiologic* conditions will serve as a sort of baseline for the discussions of pathologic conditions presented in Parts II and III.

I. QUANTITATIVE ASSAYS OF "SENSIBLE" SWEATING

A. METHODS

It is obvious that the methods of assaying the quantity of sweat delivered to the skin surface are the backbone of all data on quantitative disturbances in sweat delivery.

For more than three centuries, measurements of the "*total perspiration*" (all water loss from skin, respiratory tract, etc.) have been performed by means of measure-

ments of changes in the weight of the body; and measurements of the *cutaneous perspiration* ("insensible" plus varying fractions of "sensible" perspiration from the skin) by means of air-tight containers, adapted to the skin surface and provided with hygrometric devices, have been employed for more than 150 years.

More recently, other methods have been introduced which, in the hands of experienced investigators, permit assaying of the *total cutaneous* perspiration, i.e., of the sum of the "insensible" and "sensible" perspiration on circumscribed skin areas. The apparatus employed in these methods are provided with collecting chambers, which fit tightly to small circumscribed areas of the skin surface. From these chambers the water vapor discharged by the skin is carried by a regulated current of air or oxygen to a device for measuring the moisture. The gas-current is under manometric control, and its temperature is measured. Likewise, the temperature of the skin area under test and of the inner body (rectum) of the subject are measured by a thermocouple.

Y. Kuno devised several "perspiration apparatuses" of this kind (1), either for examinations of a subject in reclining position, or for examinations in a "sitting chamber," as well as a portable apparatus for the measurement of cutaneous perspiration. This portable apparatus is furnished with a special hair hygrometer for measuring the humidity in the sample of air, whereas in the other equipment ("perspiration chambers") the water vapor is absorbed by dried calcium chloride in small U-tubes which, with their contents, are weighed before and after the experiment. Special arrangements are provided for deliberate variations in temperature and humidity of the environmental air, and for controlled muscular exercise.

G. E. Burch and collaborators (2) led a stream of oxygen through a brass collecting chamber on the skin and caught the water vapor in aluminum coils in which the vapor was retained by freezing. The coils were weighed prior to the experiment and thereafter.

E. D. Palmes (3) measured the absorption of infrared rays by the water vapor in an oxygen current passing over small skin areas.

From 1945 to 1950 we employed a so-called "electrohygrometer"* in which an air current passed through a small chamber over the skin and thereafter through a cylinder provided with a plate which was coated with a film containing lithium sulfate. Dissociation of this salt occurred in proportion to the humidity of the air current passing through the cylinder. The resulting change in electric conductivity was measured and automatically recorded by an electrostatic amplifier system. This ingenious apparatus was useful only after tedious calibration for each individual examination. It was, moreover, a delicate machine which required frequent repairs by specially trained experts. The use of this device for clinical investigations on a large scale must await mechanical and other improvements in design and construction.

In general, all the above described methods are too intricate for serial examinations in ordinary clinical laboratories.

Another, technically less difficult approach, is the measurement of the electrical resistance of the skin, which allows an indirect appraisal of the outpouring amounts of sweat. The principle of this method, widely employed in neurologic studies of peripheral nerve injuries (4,5,6,7), is based on the observation that the resistance to the flow of a very weak direct current increases with diminished sweat gland activity, as commonly encountered in denervated skin areas. The reverse, namely a decrease in the electrical resistance, results from augmented sweating.

* This apparatus was placed at our disposal through the courtesy of Wallace Research Laboratories, Inc., Princeton, N. J.; the construction was executed by The Radio Corporation of America (RCA), Princeton, New Jersey.

The technique of measurement was described in detail by C. P. Richter (8,9) and F. G. Whelan (10). The indifferent electrode is usually fastened at the ear lobe, while the electrical resistance is practically eliminated at this site by puncturing the skin or by spreading "electrode jelly" under the electrode. A metal roller serves as the other electrode, which is used on any skin area to be tested. The resistance is determined by means of a "dermometer" recording the intensity of the current, while constant voltage is maintained.

This method was found useful for estimations of the degree of sweating not only in neurologic studies (11,12,13), but also in the investigation of dermatologic problems. H. N. Wagner (14), for example, demonstrated in two patients with congenital aplasia of the sweat glands that the electrical resistance in skin areas in which sweat glands were absent was as high as in denervated skin areas of otherwise "normal" subjects, whereas the resistance was low in the areas where sweat glands were present.

While this method is of value for comparative examinations, unfortunately it does not permit any quantitative determination of the actual amount of sweat present in a given skin area under investigation. Moreover, the interpretation of the results may occasionally be difficult, since it is conceivable that the resistance to the galvanic current might be influenced also by various factors other than the amount of sweat on the skin surface. To our knowledge, it is still unknown in which manner, and to what extent, the resistance is influenced by the different forms of sweat retention just below the skin surface, i.e., by disturbances which are among the most common and clinically most important disorders in sweat delivery (see pages 60 to 76 and 88 to 118).

Furthermore, the method of measuring the electrical resistance was in our own limited experience not suffi-