THE TREATMENT OF HYPERHIDROSIS OF HANDS AND FEET WITH CONSTANT CURRENT*

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INTRODUCTION

It has been shown repeatedly (1) that the sweat glands respond to both thermal and psychic stimuli. Thermal sweating is a generalized process to eliminate heat and is rarely a cause for complaint. The psychic stimulation of sweating, however, can give rise to considerable difficulty. It is elicited by emotional stimuli, intellectual strain, or painful cutaneous stimuli (2). This type of sweating is localized mainly in the palmar surface of the hands and fingers, the plantar surface of the feet and toes, and occasionally on the forehead. Axillary sweating is considered a mixture of psychic and thermal sweating. Darrow describes some of the central mechanisms in psychological sweating. Among many cortical centers the pre-motor cortex appears to have a dominating influence. He has given a review on the neural-mechanisms controlling the palmar galvanic skin reflex and palmar sweating (3). The palmar sweat glands are cholinergic in their response to drugs and are innervated by the thoraco-lumbar sympathetic chain. Sweating is increased by pilocarpine and acetylcholine and is inhibited by atropine. Palmar and plantar sweating is relatively little influenced by a rise in temperature (2). Palmar sweat represents one of the many mechanisms of preparation for activity. In sleep, the palms tend to be dry. This holds true even in hot weather when the body may be perspiring profusely but the palms remain dry. Palmer (4) presents evidence to show that postganglionic stimulation is not the cause of hyperactivity of the palmar and plantar sweat glands. Since most of the symptoms date back to childhood, she raises the question whether the defect is purely functional or whether the symptoms can result from a congenital anomaly of the autonomic nervous system.

Hyperhidrosis may become so severe that it interferes seriously with normal and social activities of the individual. Many patients complain of social ostracism and of the inability to carry on regular vocations. In many of these patients hyperhidrosis of the hands is equally severe in summer or in winter. Hands and feet are usually cold and clammy to the touch. (If the patient happens to be a physical therapy student, serious difficulty in her classes of massage may arise.) Secondary skin diseases may occur. The skin will become thickened, erythematous, sodden, and tender. As a result of maceration of the corneal layer, secondary dermatitis can develop. In many instances the secondary dermatitis will disappear as soon as the hyperhidrosis has been alleviated. Pernet (5) and Hitch and Hanson (6) describe the relation between hyperhidrosis and symmetrical lividity of the soles. Microscopically there is marked parakeratosis and hypergranulosis with generalized edema and vascular dilatation. There is moderate subacute and chronic cellular infiltration, often concentrated perivascularly.

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The severe social and economic disturbance which this relatively harmless disease can produce has resulted in many different therapeutic efforts.

PREVIOUSLY SUGGESTED TREATMENTS FOR HYPERHIDROSIS

Many different types of therapy have been recommended to relieve hyperhidrosis of the palms and soles. Sutton and Sutton (7), as well as Stelwagon (8), find a mild astringent lotion of zinc sulfate, tannic acid, and alum valuable in treatment. The liquid is applied for several minutes and the part is dried and powdered with boric acid, to which a small percentage of salicylic acid has been previously added. L. Weiss (9) finds that a bath of permanganate of potash is much better than salicylic acid. Stillians (10) recommends a twenty-five per cent solution of aluminum chloride. R. S. Weiss and Marcus (11) find that aluminum phenolsulfonate (active ingredient of most deodorants) is equal to or superior to aluminum chloride as an anhidrotic, and the possibility of the development of contact dermatitis is less in solutions of stronger concentration. White and Smithwick (12) state that the application of five per cent formalin will bring about some local reduction in sweating but at the price of maceration and irritation of the skin.

Sutton and Sutton (7) consider X-ray as an excellent therapy to relieve the condition. Mild exposures are given at bi-weekly intervals until the activity of the sweat glands is inhibited to a sufficient degree. In obstinate cases the patient may have to return occasionally for further treatment. White and Smithwick (12) believe that although the sweat glands do atrophy under radiation the treatment must be pushed to the point of risking a chronic dermatitis. Since the chronic dermatitis would be more serious to the patient than the hyperhidrosis, the X-ray treatment would appear to be undesirable in this condition.

White and Smithwick (12), Adson (13) and Pearl and Shapiro (14) recommend sympathectomy in severe cases where conservative measures give no relief and the condition is affecting the personal welfare of the patient. The presence of a Horner's syndrome and a permanent pupillary dilatation are objections to this procedure. The temporary results of sympathectomy would hardly warrant its application in a minor affection such as hyperhidrosis.

White and Smithwick (12) found relief in one case of palmar hyperhidrosis by a paravertebral infiltration of alcohol around the upper three thoracic ganglia, with only a single night's hospitalization and without any interruption of the patient's employment. However, they believed that there was considerable risk of incomplete results and some risk of producing troublesome intercostal neuritis, and they never repeated the procedures.

Mager (15) recommends using rubber fingers padded with material to absorb moisture between the toes for cure of hyperhidrosis.

Ichihashi (16) applied various solutions by ion transfer at both poles. An effective reduction of sweat resulted only under the anode with atropine, histamine, and formalin. Agaricin, urotropin, resorcinol, alum, acetic acid, trichloracetic acid, boric acid, salicylic acid, and hydrochloric acid show no effect at either pole. As most effective he recommends using a seven and a half to ten per cent

solution of formaldehyde with a current of one-third to one-half milliamperes per square centimeter for ten minutes, repeated three or four times to stop palmar hyperhidrosis for one and one-half or two months. Following treatment a strong hornization of the skin occurs followed by a desquamation. Fries (17) treats uncomplicated hyperhidrosis with three daily treatments of one per cent formaldehyde solution with complete remission for approximately one month. The length of his treatments is twenty minutes at ten to twelve milliamperes. Since formaldehyde is not ionizable, this heroic method does not appear to be a logical one.

Lahey and Byrnes (18) recommend a zero point two per cent copper sulfate solution for the treatment of dyshidrosis. Treatments are given on alternate days, beginning with a test period of two minutes to detect the presence of copper sensitivity. Subsequent treatments cover six minutes. Their work resulted in complete healing in forty-eight per cent of dyshidrotic cases, significant improvement in twenty-five per cent, and complete failure in seventeen per cent. They recommend a keratolytic agent to complete the treatment.

In treatment of symmetrical lividity of the soles Hitch and Hanson (6) tried a two per cent solution of aluminum acetate which relieved the hyperhidrosis promptly. At the end of three months the hyperhidrosis still had not returned. They also used intravenous administration of calcium thiosulfate with the eruptions rapidly fading. In another case the feet were painted with a forty per cent solution of formaldehyde, and one week later the hyperhidrosis was greatly improved. With continued weekly treatment, the eruptions and hyperhidrosis progressively decreased. The feet appeared essentially normal in about three weeks. Parkhurst (19) treated his cases with twenty-five per cent solution of aluminum chloride twice daily. It was necessary to continue the astringent two days a week to prevent reoccurrence, but remissions were obtained.

The many attempts at treating this disease with different methods and the inclusion of such techniques as sympathectomy emphasize the extent of interference with daily living which can result from this disease. A simple harmless method of treatment appears desirable.

METHODS

A simple quantitative sweat test was developed which can be done with equipment usually available in the Physical Medicine Department. This sweat test gave four major gradations of sweat secretion each of which could be divided into three subgrades so that a total gradation of twelve steps in sweating could be measured. The test depends on a color change, and permanent test grades could be prepared by means of color photography. A statistical analysis of the reliability of the test for grading and of the reliability of the test for repeated performance was done. It was found that the coefficient of reliability for grading was 0.956 for the feet and 0.957 for the hands. It was found that the coefficient of reliability on repeated performance was 0.977. The details of this sweat test will be published elsewhere (20). It was used in all experiments to be described. A sweat level of minus two or lower was found to be normal in most normal

individuals. It was found that patients with hyperhidrosis were completely relieved of their complaints when the sweat level had decreased below this value.

Aluminum chloride ion transfer method. Most commercial deodorants contain aluminum in one form or another. Some effect of aluminum in the treatment of hyperhidrosis has been reported in the literature (8, 10, 11). We have investigated whether the effect of the aluminum ion could be improved by introducing it into the skin by the ion transfer method. An initial experimental series of fifteen patients, young men and women of college age, was treated by this method.

Treatments were given to one hand or one foot only, the other hand being used for control. Different electrodes were tried. It was found that the simplest and most successful method of application was an active electrode consisting of a large pan with a piece of sheet aluminum covering the bottom. The sheet aluminum is covered with a heavy layer of cellucotton which is saturated with a ten per cent aluminum chloride solution. The hand or foot is placed on this electrode. The active electrode is always the positive electrode. In areas where skin eruption existed as a result of the hyperhidrosis, cracks appeared in the skin which often extended into the dermis layer. Frequently, considerable pain developed in the areas and they have to be covered by an insulating layer. Either collodion or cold cream proved effective in this respect. Increase in current was possible after this preparation. It was usually found that in a few treatments these areas healed and needed no further protection so that then the entire skin area could be treated. The active electrode was connected with the positive pole of a direct current generator. The current used was determined by the patient's tolerance. A test for the presence of skin sensation was performed before the start of each treatment series. Sweat tests were given before each treatment, and after the hyperhidrosis had disappeared were continued until abnormal sweat secretion returned. The first sweat test usually showed a maximal or near maximal sweating which was attributed to apprehension on the patient's part to a treatment involving electricity. Treatments were continued until the patient felt that sweating had been reduced to a level which no longer interfered with his daily living. This level usually fell between one and minus two. In the initial series of fifteen patients who were treated with a ten per cent aluminum chloride solution by ion transfer, sweat secretion was reduced to the minus two to one level with five to thirteen treatments. The effect of the treatment lasted from three to nine weeks. Figure 1 shows a typical result in an individual patient. Treatments were given on alternate days. Satisfactory drying occurred in seven treatments. After this, sweat tests were spaced as indicated by the line in the upper right corner. The remission of symptoms lasted six weeks. The temporary effect of the aluminum ion transfer was present in all cases. The duration of the remission showed considerable variation. After sweat secretion has increased, a new series of treatments will again reduce the sweat secretion to the same low level as after the first series. Three cases were followed through many repetitions of the series. The second series was started after sweat secretion had returned to maximal. There appeared to be no change in the number of treatments necessary to obtain the remission of symptoms or in the length of time the remission lasted.

Some experiments were performed with asbestos paper wrapped around the hand. This method of application was unsuccessful compared to the method described before. Replacement of the aluminum chloride by 0.25 per cent solution of copper sulfate while using the asbestos paper technique was tried in a few cases without marked improvement in results. Changing the electrodes to the pan type in the same patients then resulted in satisfactory drying.

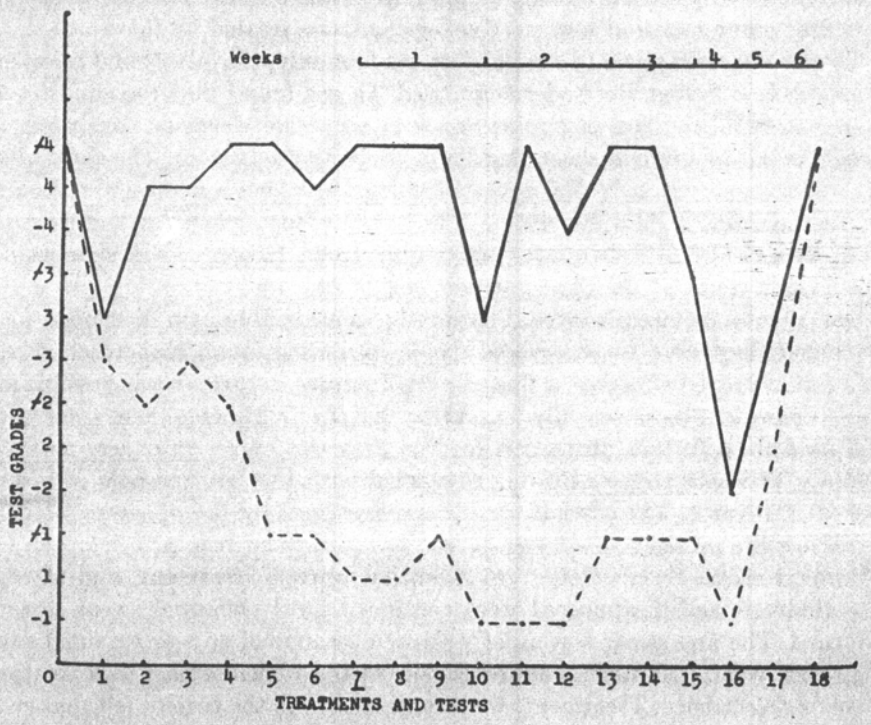

Fig. 1. Effect of aluminum chloride ion transfer on hyperhidrosis of the feet.
Patient B. E. B.: Thirty year old white female.
Horizontal coordinates: Order of sweat tests given.
Vertical coordinates: Result of sweat test (see text).
Solid line: Left foot (control).
Interrupted line: Right foot (treated after tests 1–7).
Treatments to right foot given immediately following tests 1–7. Ion transfer with 10% aluminum chloride to right foot. Average current used 23 milliamperes.
Line at top of the figure indicates weeks elapsed since discontinuation of treatment (last treatment after test 7).

Treatment with direct current only. In our study of the literature we were impressed by the results of Ichihashi (16) in which formaldehyde ion transfer appeared to be a very effective method in reducing sweat secretion. Formaldehyde is not ionizable; therefore, one would question whether this treatment was actually an ion transfer treatment. Two possible explanations can be suggested. The first is that the results might have been due to the direct action of formaldehyde which in itself does have a sweat decreasing effect (12, 17). The other possibility would be that the current itself might have an effect on the sweat secretion in-

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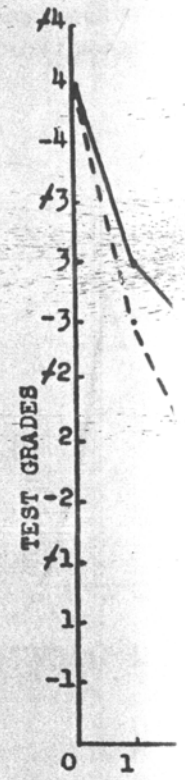

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dependent of the use of any specific ions. We, therefore, decided to replace the aluminum chloride solution with tap water which contained no significant amount of aluminum according to a chemical analysis.

An initial series of eleven patients was treated with tap water with the same technique as has been described previously. Either one hand or one foot was

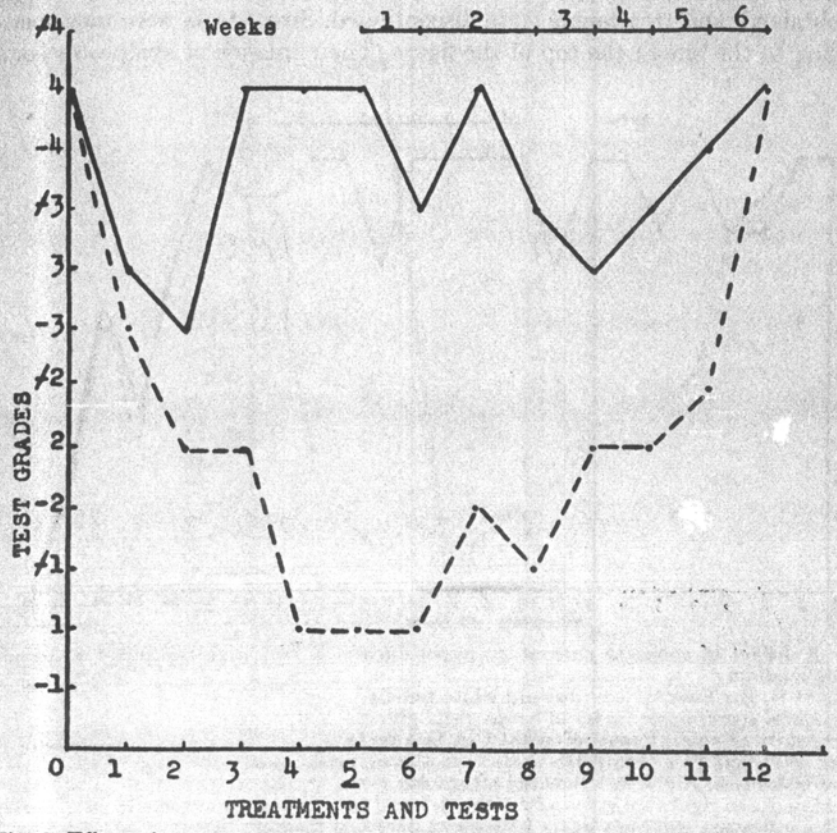

Fig. 2. Effect of constant current on hyperhidrosis of hand with tap water as current carrying medium.
Patient M. E. B.: Twenty-one year old white female.
Horizontal coordinates: Order of sweat tests given.
Vertical coordinates: Results of sweat test (see text).
Solid line: Left hand (control).
Interrupted line: Right hand (treated after tests 1–5).
Treatments to right hand given immediately following tests 1–5. Constant current application with tap water as current carrying medium. Average current used 16 milliamperes.
Line at right top indicates weeks passed since discontinuation of treatment (last treatment after test 5).

again treated with the contralateral part remaining as a control. It was found that the reduction in sweat secretion was obtained in from five to thirteen treatments and that the after effects of the initial series lasted from three to seven weeks.

Figure 2 shows an example of treatment of one hand, the other being used as a control. Treatments were again given on alternate days. Satisfactory drying

occurred after four treatments. Treatments were discontinued after the fifth, and sweat tests were spaced as indicated by the line at the top of the figure. The remission of symptoms lasted six weeks.

Figure 3 shows the course of events in a patient whose feet were treated with constant current using tap water as the current conducting medium. Treatments were given on alternate days. After nine treatments a satisfactory result had been obtained, and treatments were discontinued. Sweat tests were now spaced according to the line at the top of the figure. The remission of symptoms lasted

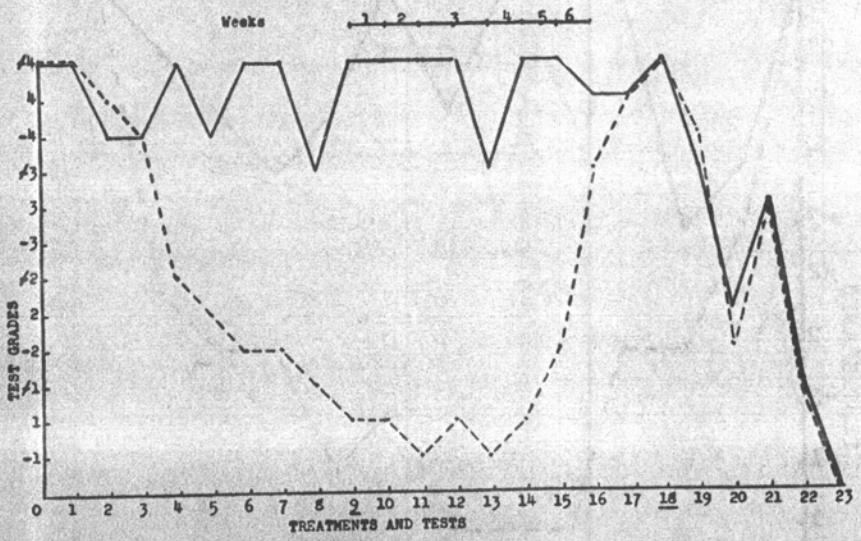

FIG. 3. Effect of constant current on hyperhidrosis of feet with tap water as current carrying medium.
Patient B. B.: Twenty-five year old white female.
Horizontal coordinates: Order of sweat tests given.
Vertical coordinates: Result of sweat test (see text).
Solid line: Left foot (control).
Interrupted line: Right foot (treated after tests 1–9).
Treatments to right foot given after tests 1–9 and to both feet after tests 18–23. Constant current application with tap water as current carrying medium. Average current used 13 milliamperes.
Line at right top indicates weeks passed since discontinuation of treatment to right foot only.

six weeks. After sweat secretion had again become equal in both feet, a treatment series was started on both feet simultaneously. It was found that in six treatments both feet became dry.

In two of the eleven cases aluminum chloride ion transfer was followed by a treatment with constant current only and the use of tap water as a current-transmitting agent. The number of treatments needed in either case was essentially the same. The remission lasted the same length of time after the treatment with constant current only, as it did after the treatment with constant current aluminum ion transfer. In one patient one hand was treated with aluminum

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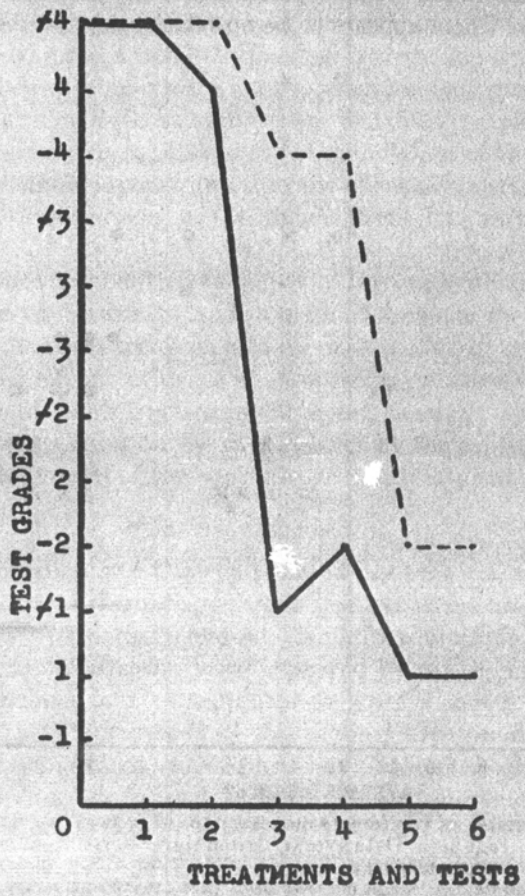

FIG. 4. Comparison of aluminum chloride ion transfer treatment and constant-current-only treatment in hyperhidrosis.
Patient I. W.: Twenty-one year old white male.
Horizontal coordinates: Order of sweat test and treatment.
Vertical coordinates: Result of sweat test (see text).
Solid line: Left hand treated with constant current only (tap water).
Interrupted line: Right hand treated with 10% aluminum chloride ion transfer.
Average current used for both hands 23 milliamperes.

what more effective than the aluminum chloride ion transfer. This difference is not significant, however.

With the elimination of an active ion to be transferred into the tissues the question of polarity of the current can be raised. We have treated a large number of patients with either the positive or negative electrode and have found that the

effect occurs at either electrode. The positive electrode, however, is slightly more efficient than the negative electrode which usually makes a difference of about one or two treatments.

The current strength tolerated by the patients is of the same order of magnitude for the aluminum ion transfer patients and the patients treated with constant current only. There appears to be no relationship between the number of

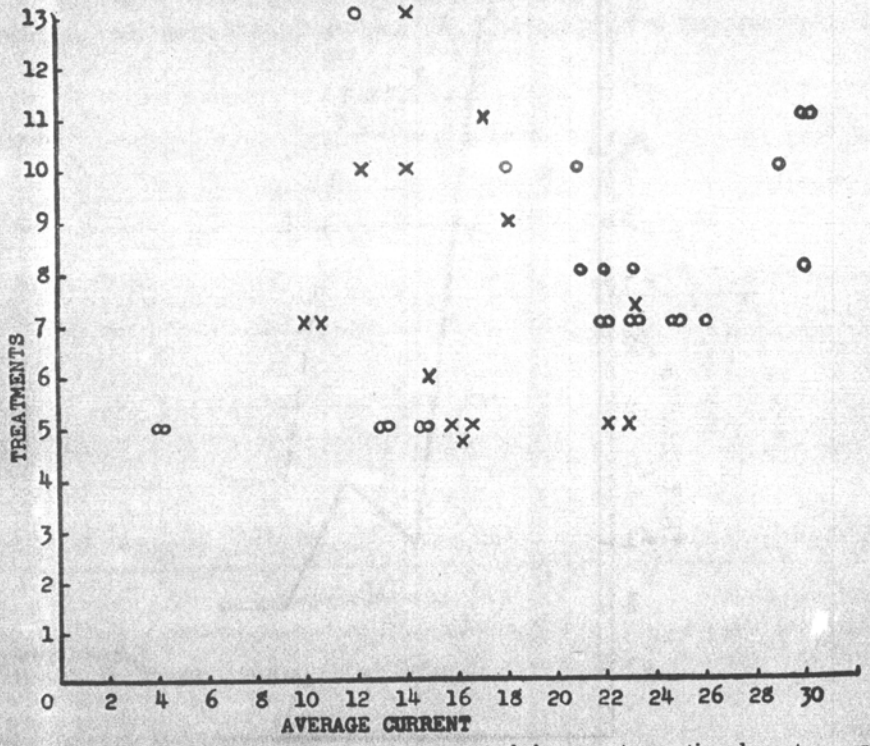

FIG. 5. Plot of number of treatments necessary to bring sweat secretion down to normal level and average current used. Data averaged from thirty-seven treatment series on twenty-six patients of initial experimental series.

Horizontal coordinates: Average current used in a treatment series.

Vertical coordinates: Number of treatments needed in a series to obtain satisfactory drying.

Circles: Aluminum chloride ion transfer.

Crosses: Constant-current-only treatments with tap water as current carrying medium (see text).

treatments needed and the current strength used as indicated in figure 5. It should be remembered, however, that the current used was always the maximum current which the patient would tolerate. No effort has been made at the present time to study the relationship between current strength and the number of treatments needed over a wider range of current strength. Figure 5 shows that there is no difference between the number of treatments needed to obtain adequate drying in the two methods of treatment. The patients treated with tap water

appear to have smaller spread of current tolerance than those treated with aluminum ion transfer. No significance is attached to this finding.

In order to determine whether the effect of constant current on the sweat secretion is a direct effect on the sweat glands or an effect on the nerves supplying them, a mecholyl ion transfer was given to the completely dried hand in a series of patients. The mecholyl ion transfer was given with an asbestos paper soaked in mecholyl chloride wrapped around the hand so that the ion was transferred into the entire hand. It was found that a very intensive sweating of the back of the hand occurred; the palm of the hand, however, remained completely dry. In view of the fact that mecholyl is capable of direct stimulation of the sweat glands, it would appear from these experiments that the effect of constant current on the sweat glands is a direct action on the glands themselves rather than on their innervation.

A few of our patients submitted to biopsy of the treated area. No evidence of anatomical changes in the sweat glands was found. Some of the sweat glands appeared as though the sweat secretion in some of the cells had continued after the treatment, but there was no evidence of an overfilling of the sweat glands which might have indicated an obstruction in the sweat canal. It appears, therefore, that a direct inhibitory effect on the sweat glands by the constant current is the reason for the effectiveness of the constant current treatment of hyperhidrosis.

CLINICAL APPLICATION

A total of one hundred and thirteen patients has been treated with constant current since the initial experimental series. The treatment has proven effective in one hundred and three patients treated. Six patients in whom constant current treatment alone was not effective were improved by subsequent aluminum ion transfer. In the remaining four inadequate or no improvement at all was obtained.

The practical clinical application of this method becomes extremely simple. For the treatment of the hands two enameled or plastic photographic trays were used with a metal electrode lying flat on the bottom. Aluminum plates can be used and have advantages because of their stiffness and easiness of cleaning, but any electrode material commonly used in a Physical Medicine Department is equally adequate. The electrode is covered with a heavy layer of cellucotton. The trays are filled with tap water to such a level that the palm of the hand when resting comfortably on the cellucotton is covered. We usually apply a thin layer of cold cream or vaseline on the sides of the fingers about at the level at which the surface of the water will touch the hand so that no painful surface effect is evident. All cracks and open areas on the palmar surface of the hand are covered with cold cream or collodion. After a few treatments when the hands begin to dry up, this will no longer be necessary. It should be realized that these cracks are often the result of continued hyperhidrosis and that the treatment is not aimed at treating these spots but at an over-all reduction of the sweat secretion which will also result in healing of secondary maceration and dermatitis. In view of the fact that hyperhidrosis is always symmetrical, two active electrodes are used and no dis-

persive electrode is needed. The polarity of the electrodes is changed from treatment to treatment. The treatments last from twenty to thirty minutes; the current intensity depends on the tolerance of the patient and the treatments are repeated daily or on alternate days until the hyperhidrosis has disappeared. The patient is informed about the temporary character of the effect and told to return when hyperhidrosis again develops. The effectiveness of the treatment is such that no urging to return is necessary. The treatment of the feet is essentially similar to that of the hands. Photographic trays can again be used. Earthen crocks with the electrode at the bottom and again covered with cellucotton have proven equally effective. Any constant current generator which is able to give an adequate current strength is satisfactory. In view of the fairly large area which is being treated, current strength up to fifty or seventy-five milliamperes is sometimes necessary. As in all repeated ion transfer procedures, it is often found that the current tolerance increases in subsequent treatments. Our tap water is a good enough conductor without the need for addition of any salt. In localities where the water is unusually salt-free, this may be necessary. All usual precautions against sudden interruption of the treatment-current must be carefully observed in view of the strong currents used.

SUMMARY

A simple effective treatment for hyperhidrosis of hands and feet is described. One hundred and thirteen patients have been treated with an application of constant current. In one hundred and three of these drying occurred in five to thirteen treatments with an after-effect lasting up to three months. In six additional patients drying was obtained with aluminum ion transfer. In four patients the treatment resulted in unsatisfactory or no improvement. The effect appears to be due to a a direct inhibitory effect on the sweat glands.

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