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Management of Postsurgical Hyperhidrosis With Direct Current and Tap Water

Background and Purpose. Excessive sweating, known as hyperhidrosis, involves the eccrine sweat glands of the axillae, soles, palms, and/or forehead. The use of iontophoresis to reduce or eliminate excessive sweating has been described since 1952. The purpose of this case report is to describe the use of tap water galvanism (TWG) using direct current (DC) with a patient who had postsurgical hyperhidrosis. **Case Description.** The patient was a 36-year-old male electrician with traumatic phalangeal amputation and postsurgical development of hyperhidrosis. Tap water galvanism was administered using a DC generator, 2 to 3 times per week for 10 treatments. The patient's hands were individually submerged in 2 containers of tap water with the electrodes immersed directly into the containers. Each hand was treated with 30 minutes of TWG at 12 mA. Hyperhidrosis was measured by a 5-second imprint and subsequent tracing of the left hand placed on dry paper toweling. **Outcomes.** The patient's hyperhidrosis decreased from the full left palmar pad, with a surface area of 10.3×12.0 cm, to a reduced area of wetness that covered a 2.2×2.7-cm area. The patient returned to work as an electrician without needing absorbent gloves, which had prevented him from performing electrical work. **Discussion.** Following use of TWG, the patient's palmar hyperhidrosis returned to normhidrosis. [Gillick BT, Kloth LC, Starsky A, Cincinelli-Walker L. Management of postsurgical hyperhidrosis with direct current and tap water. *Phys Ther.* 2004;84:262–267.]

Key Words: *Electrotherapy, Hyperhidrosis, Iontophoresis, Physical therapy.*

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Excessive sweating, known as hyperhidrosis, can affect people both socially and functionally. This relatively common disorder of unknown origin can focally involve the eccrine sweat glands of the axillae, soles, palms, or forehead, or can be generalized and involve several areas. The sweat glands responsible for focal hyperhidrosis are eccrine glands innervated by anatomically sympathetic, but functionally cholinergic, fibers.¹ The neurotransmitter involved, therefore, is acetylcholine. Hyperhidrosis can be categorized according to the stimuli that trigger the sweating response. These stimuli are associated with sites within the nervous system where neuronal impulses for sweating originate. Stimuli for emotional sweating (mental or sensory hyperhidrosis) originate from a cortical reflex, gustatory sweating (medullary origin), thermoregulatory sweating (hypothalamic origin), hyperhidrosis following spinal cord injury, disease, or transection (spinal origin), and local sweating (axonal reflex).¹ Hyperhidrosis is

Authors describe the use of tap water galvanism in a patient who sustained traumatic digital amputation, with subsequent onset of hyperhidrosis involving the left hand.

usually idiopathic, resulting from neurogenic overactivity of the sweat glands.²

Several interventions for hyperhidrosis have been reported. Anticholinergic and antidepressant medications have been found to have side effects,¹ solutions of aluminum chloride or zirconium salts form a temporary plug in the sweat gland,³ and sympathectomy carries the risk of compensatory sweating.^{4,5} Botulinum toxin, which inhibits the release of acetylcholine, has been reported to induce anhidrosis for a median duration of 7 months following its injection into hyperhidrotic palms and axillae; however, a lasting end of the symp-

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Professor Kloth, Mr Starsky, and Ms Cincinelli-Walker contributed to concept/research design of the manuscript. Ms Gillick and Professor Kloth contributed writing. Ms Gillick and Ms Cincinelli-Walker performed data collection and provided the patient. Ms Gillick contributed project management, facilities/equipment, and clerical support. Professor Kloth, Mr Starsky, and Ms Cincinelli-Walker provided institutional liaisons. Professor Kloth and Ms Cincinelli-Walker provided consultation (including review of manuscript before submission).

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toms has not been observed after numerous treatments.^{6,7} Another intervention that has effectively reduced or eliminated excessive sweating for variable periods of time is electrical stimulation.⁸

The use of electrical stimulation to reduce or eliminate excessive sweating has been described since 1952.⁴⁻⁷ In a review of the literature on the management of hyperhidrosis of the hands and feet, Bouman and Lentzer⁹ reported that other investigators claimed success with the use of iontophoresis and chemicals such as aluminum chloride, potassium permanganate, and formaldehyde. Recognizing that formaldehyde is not ionizable, Bouman and Lentzer⁹ reasoned that the positive outcomes following management of hyperhidrosis with direct current (DC) depended simply on the passage of continuous unidirectional current through the tissues without medicinal ions. Despite the absence of medicinal ions in tap water, the impurities ordinarily present in it are sufficient to conduct a current.

Bouman and Lentzer's⁹ reasoning highlights confusion of the terms "iontophoresis" and "galvanism" in the literature. *Iontophoresis* refers to the use of continuous DC to deliver medicated ionic solutions into afflicted tissues, whereas *galvanism*, a term first proposed by a German scientist in 1799,¹⁰ refers to the therapeutic effects of passage of unidirectional continuous DC through tissues immersed in tap water. Apparently, previous investigators did not distinguish between iontophoresis and galvanism, because virtually all of the publications we found that described the use of DC to manage hyperhidrosis referred to the intervention as "iontophoresis." The proposed mechanisms by which electrical stimulation ameliorates hyperhidrosis include perturbation of an endogenous electrical gradient that alters sweat flow and obstruction of the eccrine sweat glands, resulting in inactivation of sweat glands through an unknown mechanism.¹¹

Researchers have demonstrated the successful use of "tap water iontophoresis" with DC or alternating current (AC) for management of palmar and plantar hyperhidrosis. In a study by Reinauer and associates,¹² 25 patients between 8 and 35 years of age were managed with tap water iontophoresis using either AC (n=5) or combined therapy of AC/DC (n=10) compared with DC (n=10) alone. A normal palmar sweating level, which they defined as "a gravimetrically measured constant palmar sweat rate of less than 0 to 20 mg/min,"^{12(p167)} was achieved after 11 treatments with DC. The authors reported that a combination of AC and DC "tap water iontophoresis" produced similar favorable responses. However, sinusoidal AC treatments had virtually no lasting effect. The authors speculated that the decrease in production of sweat involves "a functional disturbance

of the sweat gland secretory mechanism by interrupting the stimulus-secretion-coupling"^{12(p168)} mechanism.

Using "tap water iontophoresis" administered with DC at 10 to 20 mA, Shrivastava and Singh¹³ managed 30 patients with hyperhidrosis of the palms and soles and reported favorable clinical results, with normhidrosis occurring after an unspecified number of sessions. They also investigated the effects of placing the hands or feet into one container of tap water with 2 electrodes or placing the hands or feet into 2 separate containers of tap water, each with one electrode. The number of treatments required and amount of current were greater with the single-container method (average of 14.1 treatments at 20–25 mA for 20 minutes for the one-container method versus average of 7.1 treatments at 10 mA for 15–25 minutes with the 2-container method). The effects of their treatment lasted a mean of 8.6 months with the electrodes in the same pan at 25 mA for 20 minutes. With separate pans at 10 mA for 15 minutes, the treatment effect lasted 8.0 months versus 3.37 months at 10 mA for 25 minutes. For all groups studied, the average remission period was 6.26 months.

Akins et al¹⁴ explored the use of a DC stimulator for home use with the patients adjusting current intensity to maximum tolerable output. They used the Fisher Dri-onic Unit,* a battery-operated stimulator that provides DC for TWG. The stimulator, which produces an output of 7 to 20 mA, was used for the management of hyperhidrosis of the palms, soles, or axillae. Current amplitudes and treatment durations were not specified. The researchers found that, after 20 consecutive days of intervention, all 10 hands treated had decreased sweating as measured using Persprint paper† and photodensitometry.

In a descriptive account, Levit¹⁵ reported that a now-obsolete device called the RA Fischer Galvanic Generator successfully managed plantar and palmar hyperhidrosis. This stimulator delivered up to 90 V to drive up to 20 mA of DC into the skin. Based on his observation that the anode may be more effective than the cathode for suppressing perspiration, Levit¹⁶ advocated reversing the polarity for the second half of the 20-minute treatment.

Stolman¹¹ described the use of "tap water iontophoresis"—90 V, 12 to 20 mA of DC for 20 minutes, switching polarity after 10 minutes—to manage palmar hyperhidrosis in 18 patients. Intervention was performed 3 times a week for 3 weeks using an RA Fischer Galvanic Generator. Stolman documented reduced sweating in 15 of the 18 patients as evidenced by starch-iodine imprint.

* General Medical Co, 1935 Armacost Ave, Los Angeles, CA 90025.

† Milton Roy Co, Analytic Products Division, 201 Ivyland Rd, Ivyland, PA 18974.

Table.
Events Concerning the Management of a Patient With Hyperhidrosis

Day Since Injury	Procedure
0	Date of injury Internal fixation of the left distal radius and ulna and left palmar forearm compartment release Amputation to distal interphalangeal joint digits II and V Amputation to the proximal interphalangeal joints for digits III and IV
3	Split-thickness skin graft to left palmar forearm
6	Began hand rehabilitation Patient examined for therapy
34	Patient first noticed hyperhidrosis on left hand
138	First TWG ^a treatment
163	Last TWG treatment

^a TWG=tap water galvanism.

Because the evidence for the management of hyperhidrosis with electrical stimulation reported in clinical studies suggests that tap water administered with DC is effective, we chose to use this method for managing a patient who developed hyperhidrosis following surgery. In reviewing the literature, we were unable to find any reference that addressed development of hyperhidrosis following a traumatic incident.

Case Description

Patient

The patient was a 36-year-old male electrician who caught his left hand in a cable puller machine. When he attempted to pull his left hand out with his right hand, he also injured that hand, which involved fracture of the distal phalanx and injury to the nail bed of digit V. The left hand had partial traumatic amputations of digits II to V and fracture of the distal radius and ulna. He developed a compartment syndrome in his left forearm. After his skin graft, the patient was referred for physical therapy by the orthopedic surgeon, as indicated in the Table.

Examination

During the initial examination for hyperhidrosis, the patient reported that, because of excessive wetness of his hands, he could not maintain his grasp on tools or on the steering wheel of his car. He also indicated that it was necessary to constantly carry towels or washcloths or wear cotton gloves (6 pairs a day) to absorb the excessive perspiration. The hyperhidrosis became an occupational hazard for him as an electrician because the gloves he wore to absorb sweat decreased his dexterity while manipulating wires and tools. The patient's goal was to reduce the amount of sweating in order to return to

work and for cosmetic and social reasons. The patient was initially being treated for his range of motion, edema, and strength deficits; yet, as his hyperhidrosis became more apparent and prohibited his return to work, we recognized that intervention for this diagnosis was essential. Informed consent was obtained for purposes of release of health information in this case report.

Intervention

Tap water galvanism was administered 2 to 3 times per week for 10 treatments using an obsolete DC generator (Fisher Co Inc). In addition to TWG, the patient received occupational therapy and physical therapy to the hand twice a week that consisted of muscle strengthening exercises and a 30-minute lifting circuit of up to 22.7 kg (50 lb), ultrasound for scar mobility, range of motion, and work simulation. The patient had an average of 5 treatments per month for 4 months, for a total of 20 treatments, without observable evidence of reduced sweating prior to initiating electrotherapy.

During TWG, the patient's hands were individually submerged in 2 trays (38×26×8 cm), each filled with 2 L of tap water that was maintained at 21°C (70°F), or room temperature, for patient comfort with one electrode immersed in each tray. The water covered the palmar surface of both hands. We treated each hand with 30 minutes of TWG at 12 mA and reversed the polarity after the first 15-minutes of intervention. Thus, both hands received anodal and cathodal TWG at the same dosage of current.

Following TWG, the patient's hands were dried with a cotton clinic towel. Prior to initiating TWG, hyperhidrosis was measured by taking a baseline 5-second imprint of the left hand on dry paper toweling. This hand was measured alone because it exhibited the most sweating. The area of hyperhidrosis on the paper toweling was determined by immediately tracing the borders of saturation. The tracing length and width were then measured to the nearest millimeter. At the time this method was the most readily available to us in the clinic. Measurements of hyperhidrosis were greater in the patient's left hand than in his right hand—a 10.3×12.0-cm area on the left hand compared with a small initial 1.0×1.0-cm area on the right palmar thenar eminence. The patient had no complaints of excessive sweating of the right hand.

Outcomes

During the course of intervention, the patient's hyperhidrosis of his left hand decreased from the full palmar pad and from phalangeal proximal pads to a partial region of reduced sweating at the palmar metacarpophalangeal pad of the second digit. The paper imprint was saturated with sweat prior to the first TWG treatment,

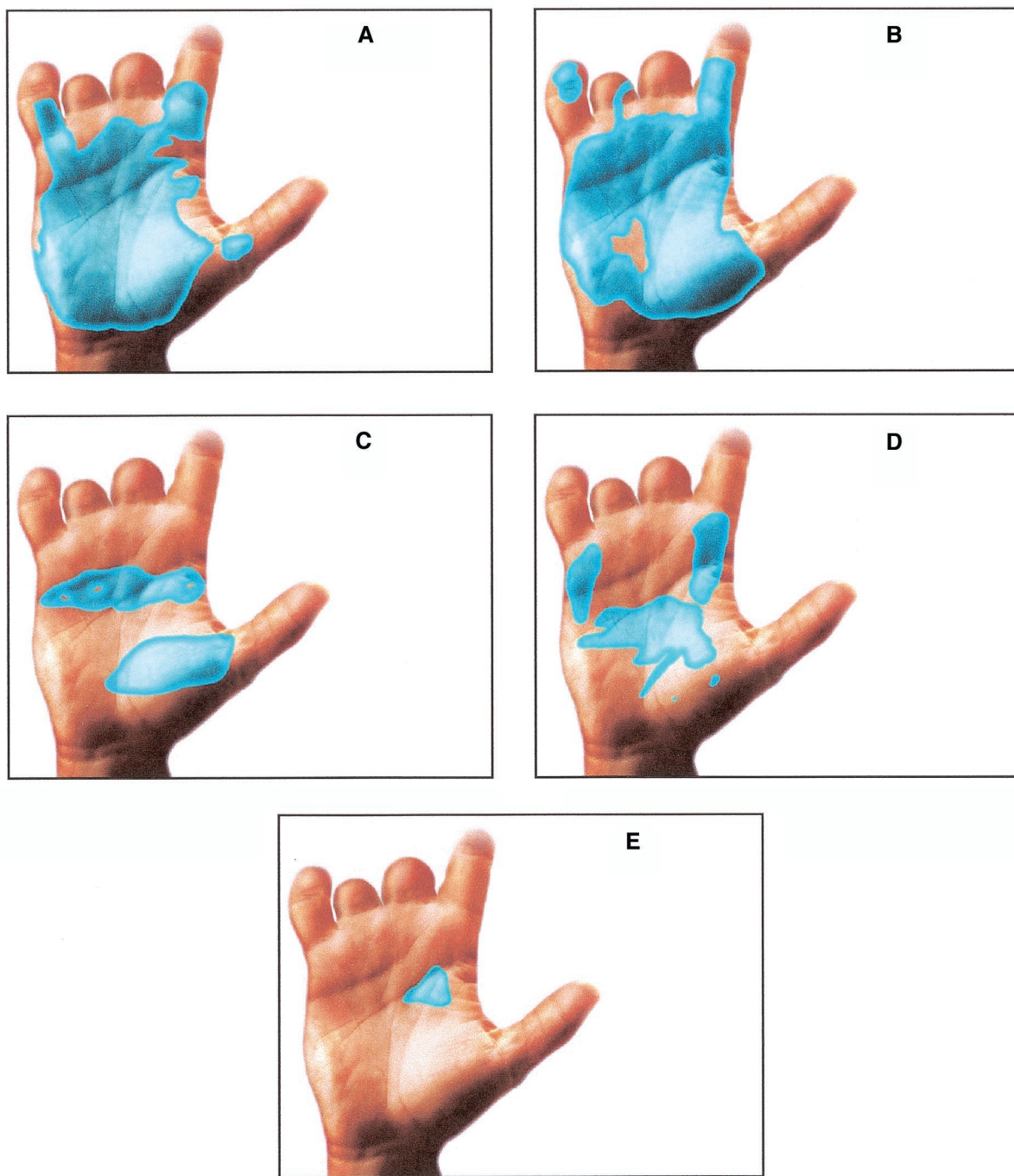


Figure.

Reduction in postsurgical palmar hyperhidrosis. This reduction occurred over the course of 1 month (10 treatments) using tap water galvanism (TWG). (A) Hand at 131 days after the injury, before TWG was initiated. (B) Hand at 138 days after the injury, the day when TWG was initiated. (C) Hand at 151 days after the injury. (D) Hand at 158 days after the injury. (E) Hand at 163 days after the injury, the day of the final TWG treatment.

with a traced surface area of 10.3×12.0 cm. After the 10 treatment sessions, the traced surface area of saturation of his left hand was reduced to a 2.2×2.7 -cm area (Figure), and the small 1.0×1.0 -cm area of the right hand was reduced to normhidrosis.

The patient returned to work full-time 2 weeks after commencing TWG. At that time, he wore 2 pairs of

absorbent gloves, compared with 6 pairs prior to intervention. Following the 10th treatment, the patient did not need to wear absorbent gloves at work. Treatment for hyperhidrosis was concluded at that time, with agreement among the referring physician, therapist, and patient to follow up in the orthopedic clinic regarding status. The patient's strengthening and range of motion treatment program continued once a week for the next

2 months, with subsequent discharge with a home exercise program.

Side effects observed during TWG included temporary erythema, lasting 1 to 2 hours after intervention, as well as minimal discomfort, described as "a slight burning sensation" during the treatment session. The patient indicated that he perceived this sensation throughout his hands up to the water line around his wrists. These effects abated by the last treatment. We observed no adverse effects.

Two years after the last treatment, we telephoned the patient, and he said that he had no abnormal sweating patterns. He also said that he had continued reduction in swelling and erythema during the 2 years since therapy.

Discussion

This case report describes the use of TWG in a patient who sustained traumatic digital amputation, with subsequent onset of hyperhidrosis involving the left hand. The choice of current and intervention protocol adapted from Stolman¹¹ that we used was based on reports in the literature, which indicated that DC minimized or abated hyperhidrosis, whereas AC alone had no demonstrated intervention effect.¹² Despite the fact that the mechanism by which electrical stimulation affects hyperhidrosis is not understood, our patient's sweating decreased, and he was able to return to full-time work as an electrician. During the time the patient was receiving each of the 10 iontophoresis treatments, he experienced only redness and tingling in his hands, both of which abated 2 hours after each treatment. These outcomes are consistent with those of Stolman,¹¹ who reported marked reduction in sweating after 9 treatments with tap water iontophoresis.

Our patient's onset of hyperhidrosis occurred after surgery. During the 3-month period prior to TWG, the patient had hyperhidrosis and received physical therapy for strengthening and range of motion, and he received ultrasound to improve scar mobility. The ultrasound was used in the areas of the left volar forearm and at the distal phalangeal surgical closure sites. These interventions did not appear to have any effect on reducing the palmar hyperhidrosis during the 3-month period prior to the initiation of TWG, although we did not measure the hyperhidrosis. During the intervention with TWG, the hyperhidrosis decreased, suggesting that TWG may have had an effect. In regard to the potential irritation of the skin during TWG, a suggestion for decreasing the negative side effects of discomfort at the water line is to apply petrolatum, a nonconductor of electricity, around the wrists.¹⁷

The limitations of our case report include the accuracy of our method of determining the extent of sweating and the uncertainty of not knowing the treatment effects of positive or negative polarity alone. Future research is needed to study the effects of TWG on hyperhidrosis. Certainly, future studies using TWG for hyperhidrosis could improve measurements of the changes in sweating and estimate the reliability and validity of data obtained with this measurement method. The improvements could also determine which polarity or polarity combinations are most effective in sustaining the reduction of hyperhidrosis.

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