8. Forstrom L: Contact urticaria from latex surgical gloves. Contact Dermatitis 6:33–35, 1980
9. Medin B, Fregert S: Contact urticaria from natural latex gloves. Contact Dermatitis 6:52–53, 1980
10. Estlander T, Jolanki R, Kanerva L: Dermatitis and urticaria from rubber and plastic gloves. Contact Dermatitis 14:20–25, 1986
11. Carrillo T, Cuevas M, Munoz T, Hinojosa M, Moneo I: Contact urticaria and rhinitis from latex surgical gloves. Contact Dermatitis 15:69–72, 1986
12. Spaner D, Dolovich J, Tarlo S, Sussman G, Butoo K: Hypersensitivity to natural latex. J Allergy Clin Immunol 83:1135–1137, 1989
13. Turjanmaa K, Reunala T, Tuimala R, Karkkainen T: Allergy to latex gloves: Unusual complication during delivery. Br Med J 297:1029, 1988
14. Turjanmaa K: Incidence of immediate allergy to latex gloves in hospital personnel. Contact Dermatitis 17:270–275, 1987
15. Frosch PJ, Wahl R, Bammer FA, Maasch HJ: Contact urticaria to rubber gloves in IgE-mediated. Contact Dermatitis 14:241–245, 1986
16. Wrangsjö K, Mellström G, Axelsson G: Discomfort from rubber gloves indicating contact urticaria. Contact Dermatitis 15:79–84, 1986
17. Wrangsjö K, Wahlberg JE, Axelsson IGK: IgE-mediated allergy to natural latex in 30 patients with contact urticaria. Contact Dermatitis 19:264–271, 1988
18. Turjanmaa K, Räsänen L, Lehto M, Mäkinen-Kiljunen S, Reunala T: Basophil histamine release and lymphocyte proliferation tests in latex contact urticaria. Allergy 44:181–186, 1989
19. Turjanmaa K, Reunala T, Räsänen L: Comparison of diagnostic methods in latex surgical glove contact urticaria. Contact Dermatitis 19:241–247, 1988
20. Bommer J, Barth HP, Wilhelms OH, Schindele H: Anaphylactoid reactions in dialysis patients: Role of ethylene-oxide. Lancet 1382–1384, 1985
21. Kessler M, Cao Huu T, Mariot A, Chanliau J: Hemodialysis-associated complications due to sterilizing agents ethylene oxide and formaldehyde. Contrib Nephrol 62:13–23, 1988
22. Dolovich J, Bell B: Allergy to a product of ethylene oxide gas: Demonstration of IgE and IgG antibodies and hapten specificity. J Allergy Clin Immunol 62:30–32, 1978
23. Marshall CP, Sagona MA, Wathen RL, Ward RA, Dolovich J: Reactions during hemodialysis caused by allergy to ethylene oxide gas sterilization. J Allergy Clin Immunol 5:653–657, 1988
24. Leitman SF, Boltansky H, Alter HJ, Pearson FC: Allergic reactions in healthy plateletpheresis donors caused by sensitization to ethylene oxide gas. N Engl J Med 315:1192–1196, 1986
25. Slater JE: Rubber anaphylaxis. N Engl J Med 320:1126–1130, 1989
26. Moneret-Vautrin DA, Mata E, Guéant JL, Turgeman D, Laxenaire MC: High risk of anaphylactic shock during surgery for spina bifida. Lancet 335:865–866, 1990
27. Turjanmaa K, Laurila K, Mäkinen-Kiljunen S, Reunala T: Rubber contact urticaria: Allergenic properties of 19 brands of latex gloves. Contact Dermatitis 19:362–367, 1988

Anesthesiology
73:558–561, 1990

Segmental Manifestation of Reflex Sympathetic Dystrophy Syndrome Limited to One Finger

MARTIN H. CHESTER, M.D.*

The reflex sympathetic dystrophy syndrome (RSDS) consists of multiple symptoms, including vasomotor instability, swelling, and chronic pain involving the affected extremity.[1,2] It is a dynamic process and may progress insidiously through three stages over several months.

The clinical features of stage 1 in the upper extremity are swelling, pain, and moderate stiffness of the joints in the fingers and wrist. The burning pain may be precipitated or exacerbated by exposure to cold. The skin may be pale or red and is usually moist because of hyperhydrosis.

Stage 2 is characterized by persistent burning pain in the hand associated with marked stiffness of the wrist and fingers. Atrophy of the muscles produces weakness of the hand, and eventually, flexion deformities of the fingers. The skin usually is pale, cold, and dry.

These symptoms may subside, and the dystrophic changes frequently may be reversed with therapy. Some patients may recover spontaneously. About 20% of stage-2 patients will succumb to stage 3.[3] These patients demonstrate irreversible muscle wasting, contractures, and osteoporosis progressing to Sudeck's atrophy, eventuating in total and permanent loss of function.

The RSDS may be precipitated by catastrophic events such as cardiac surgery,[3] myocardial infarction,[4] cerebrovascular accident,[5] or spinal cord injury.[6] Conversely, it may be triggered as an exaggerated response to any minimal trauma of the hand. Examples include finger fracture, wrist sprain, and minor hand surgery, such as a nail biopsy.[7] About 3% of surgical procedures of the hand and arm may demonstrate symptoms characteristic of RSDS.[3]

* Clinical Instructor in the Department of Family and Community Medicine, University of California, School of Medicine, San Francisco, California, and Chief of the Laurel Oak Pain Clinic, Department of Occupational Medicine, Natividad Medical Center, Salinas, California.

Received from the Pain Management Clinic, Monterey, California. Accepted for publication April 16, 1990.

Address reprint requests to Dr. Chester: Pain Management Clinic, Suite C, 147 El Dorado St., Monterey, California 93940.

Key words: Measurement technique: thermography. Pain. Reflex sympathetic dystrophy: transdermal nitroglycerin.

The following case report describes an unusual manifestation of RSDS, precipitated by relatively minimal arm and ulnar nerve surgery.

Case Report

The patient was a 71-yr-old man who complained of progressive hypesthesia in the fifth finger of the right hand. There was diminished light touch, pin prick, temperature change, and position sense in the digit. Similar changes along part of the left lateral border of the palm clearly involved the ulnar nerve dermatome. Mobility and flexion strength were unchanged.

Past history included ischemic heart disease, an acute myocardial infarction in 1971, peptic ulcer, and mitral valve regurgitation. A total knee and hip replacement had been done several years previously.

Surgical exploration of the right ulnar nerve was done. A neuroma was found at the level of the medial epicondyle. In addition, a mucinous ganglion cyst was found at Guyon's tunnel. Both tumors were obviously producing compression of the ulnar nerve. These were excised, and the nerve was successfully decompressed. During the subsequent months, the surgical wound healed and normal sensation returned to the right fifth finger.

In the ensuing winter months, however, the patient became aware of a burning pain in the finger usually associated with exposure to cold. In time the pain became more severe and persistent, and was complicated by stiffness of the interphalangeal joints, impairing mobility and function. Hypersensitivity of the skin (allodynia) was exacerbated by contact with gloves and clothes. None of the other fingers of either hand was involved.

The patient was referred to the pain clinic because of the persistent pain and loss of function of the finger. Examination of the right hand revealed a cold, pale, slightly flexed fifth finger. Mobility was limited because of pain and joint stiffness. Periarticular pain and tenderness were found in the interphalangeal joints. The grip strength of the first four fingers was adequate and equal to that of the left hand. Stroking the skin with a cold alcohol sponge intensified the burning pain. Idiopathic Raynaud's phenomenon was not considered because of the joint pains and tenderness. In addition, there was persistent vasospastic ischemia associated with allodynia. On exposure to cold, he did not exhibit the characteristic Raynaud's vasospastic ischemia, in which exposure to cold is followed by painful recolorization in the digits.

A ulnar nerve block at the wrist produced warming of the finger, relief of pain and improved mobility. In view of these findings, the diagnosis of RSDS was considered highly probable.

During an "informed consent" discussion, the patient refused a stellate ganglion block, regional intravenous bretylium blockade, technetium Tc 99m bone scan, and regional nerve blocks. He did consent to noninvasive diagnostic and therapeutic procedures. Consent for the administration of transdermal nitroglycerin patches (TDNP) was obtained from the patient after a detailed discussion of the therapeutic options and risks.

A rigid protocol was followed to assure the accuracy of thermographic monitoring of the TDNP therapy. The studies were done in a controlled-temperature dimly lighted room. The patient disrobed and rested for 30 min. A TDNP was applied over the ulnar artery at the wrist. Serial thermograms of both hands were done at 5-min intervals. About 15-30 min after the application of the 5-mg patch, the patient experienced a pleasant warming of the finger, less pain, diminished hypersensitivity (diminished allodynia), and increased mobility.

The veins of the dorsum of the hand dilated, and the capillary refill time of the fifth finger decreased 30–50%. The 5-mg TDNP was applied each morning for 1 month. Thermographic studies were carried out each week. After several months of therapy, the TDNP was reduced to 2.5 mg.

At the end of the 30-day period, identical-appearing placebo patches were applied by a nurse assistant, who was blind to the nature of the placebo patch, on three random occasions in the thermography room. Serial thermography was done as described above.

After 6 months of therapy, the improvement in pain, allodynia and mobility was consistent and stable. During warm days, he was pain-free without a patch and function was satisfactory.

Results

The application of TDNP was effective in producing symptomatic improvement in pain, vasospastic ischemia, and mobility, and diminished allodynia and hypersensitivity to cold, after 6 months. The improvement was confirmed by periodic thermography studies. A typical thermogram (fig. 1A) demonstrated the vasospastic ischemia and resultant hypothermia of the fifth finger and lateral palm (ulnar nerve dermatome). The fifth finger is barely visible, which may be interpreted as hypothermia well below the "lowest" temperature on the color scale (30.2° C). The lateral palm probably received some collateral circulation and had a warmer temperature reading (30.9° C). Serial thermography after the application of the patch (5.0-mg) demonstrated color (temperature) changes within 15 min before any color changes were evident in the left hand. This was probably due to the local effect of the patch. After 30 min the warming trend in the fifth finger was evident (fig. 1B). The temperature changed from 30.2 to 33.1° C in the distal phalanx and from 30.2 to 34.8° C in the lateral palm area. The systemic effect of the patch may be seen in the other fingers of the left hand. The temperature increased from 33.1 to 34.8° C.

When the placebo patch was applied there were no changes in symptoms. After three random placebo trials the patient, who was blind to the nature of the patch, complained that "the medicine in the patch is not strong enough." The placebo tests were discontinued after three random trials.

Discussion

The atypical findings in this patient contrast with the usual manifestations of RSDS. These symptoms involve a "glove" or "stocking" area in the upper or lower extremity. In the upper extremity, for example, a bone scan with technetium Tc 99m confirms multiple joint involvement with localized pooling and increased flow.[3] RSDS in the upper extremity frequently affects the shoulder with stiffness, increasing pain, and osteoporosis.

There are few reports in the literature describing limited discrete areas of RSDS. Helms *et al.*[8] documented two cases of RSDS similar to that described in this paper. His patients had involvement of the fourth and fifth fingers of one hand. Both patients had crushing injuries to the hand and had small bone fractures. There was no trauma to the ulnar nerve in either patient.

Tietjen[9] published data from 14 cases of RSDS in the

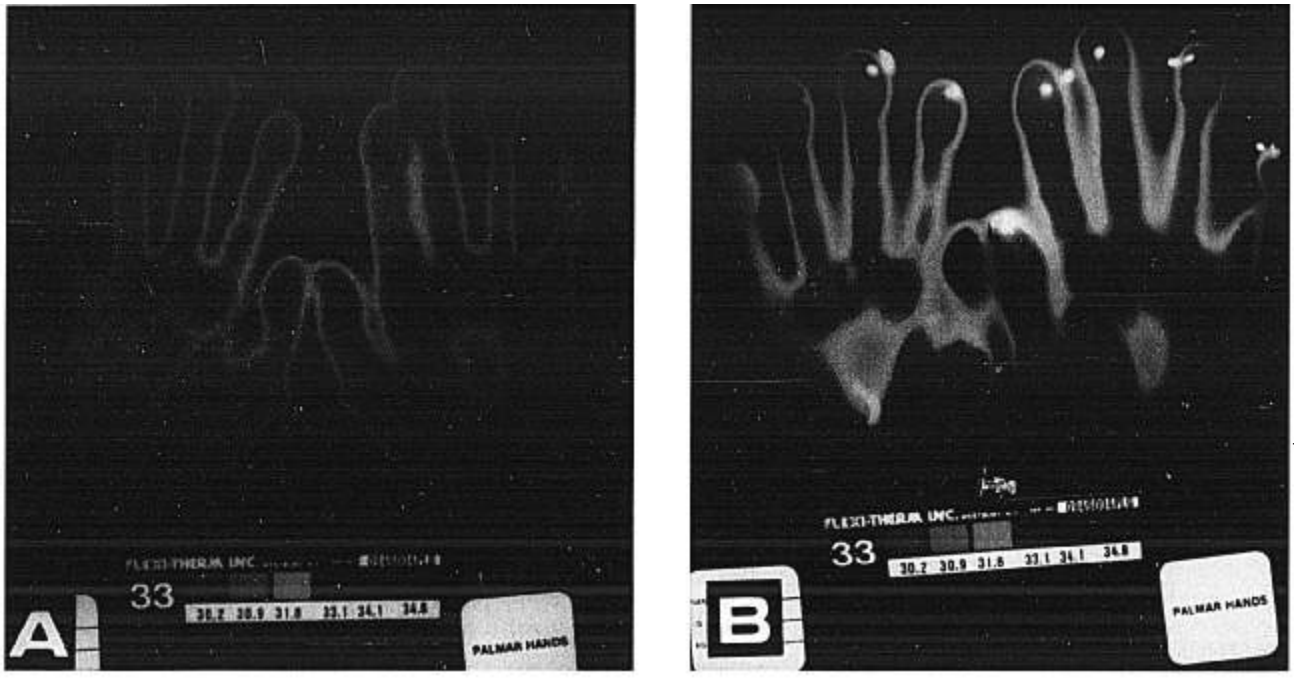

FIG. 1. (*A*) Thermograms of both hands before the application of the TDNP. The temperature of the fifth finger is below the 30.2° C "brown" level. It is only slightly visible, consequently indicating that it is to the "left" of the color code scale, "dark brown" (30.2° C). Part of the lateral palm is visible and is similar in color to the 30.2° C "brown" square on the color code scale. This may be due to collateral circulation in the areas producing a warming effect. The temperature of the fingers and palm excluding the right ulnar dermatome is consistently in the 33.1° C to 34.1° C range. (*B*) Thermograms of both hands 30 min after the application of a 5.0 mg TDNP. The fifth finger is now in the "light brown" (31.8° C) and "green" (33.1° C) range. The right lateral palm is now in the "blue" (34.8° C) range. The other fingers of both hands changed to the 34.8° C range. This is due to the systemic effect of the TDNP.

knee in 67 patients who had persistent pain following knee injuries. The diagnosis was confirmed by typical RSDS objective findings of diminished temperature, hyperhidrosis, and mottling of the skin. In addition, atrophic changes, chronic pain, and loss of mobility were observed. The clinical observations and diagnosis were confirmed by x-ray and bone scan studies. Thermography demonstrated temperature changes. The patella was "uniformly involved" in the radiographic studies, revealing osteoporosis.

Chalkley *et al.*[10] reported a case of RSDS of the penis. The patient had intensely burning pain and hypothermia of the shaft (28° C). After a caudal epidural block, shaft blood flow had increased 200%. This was associated with relief of pain. The patient recovered after the third caudal injection.

The decision in the current case to use the transdermal nitroglycerin was based on the encouraging brief reports by Hyland[11] and Jones.[12] Hyland describes improvement in hand function and symptoms in a patient with RSDS treated with 5-mg TDNP. Jones used a local instillation of nitroglycerin solution to relieve ischemic vascular spasm, in free-flap recipient vessels.

The local vasodilatory effect of nitroglycerin ointment on the capacitance vessels in patients with RSDS has been described by Martin *et al.*[13] Similar observations were reported by Hecker *et al.*[14] and Vaksmann *et al.*[15]

Eskinder and Gross's[16] pharmacologic experiments on canine saphenous veins treated with nitroglycerin may explain its local effect. They reported evidence that the nitroglycerin competes with norepinephrine at the alpha-1 binding sites at the blood vessels.

A convincing objective study of the improvement of vasospasm in Raynaud's phenomenon treated with topical glyceryl trinitrate was reported by Coppock *et al.*[17] The Nielson apparatus[18] was used to monitor finger systolic pressure after local cooling in patients with Raynaud's phenomenon. The nitroglycerin ointment produced marked reduction in peripheral arterial resistance, thus increasing the finger systolic pressure. The significant changes found in his study indicated that topical nitroglycerin produced a favorable local effect on finger blood flow.

Reports by Franks[19] and Nahir *et al.*† indicate the efficacy of topical nitroglycerin in suppressing the vasospastic attacks in Raynaud's disease.

† Nahir AM, Schapira D, Scharf Y: Double-blind randomized trial of nitroderm TTS in the treatment of Raynaud's phenomenon. Isr J Med Sci 22:139–142, 1986

Roberts's[20] hypothesis of the physiologic basis for causalgia offers a satisfactory explanation for the sequence of events in our patient. Roberts proposes that a "chain of actions" begins with trauma in peripheral tissue, which activates unmyelinated nociceptors. This nociceptor activation would be caused by the ulnar nerve surgery in our patient. The nociceptor activity excites wide-dynamic-range neurons (WDR) in the spinal cord, increasing the sensitivity of the WDR neurons to all afferent inputs. Persistent sensitization of WDR neurons will lead to allodynia when the mechanoreceptors (A-fiber) are stimulated. Roberts does concede that ischemic tissues and nerve damage also "may contribute to the pain."

In our patient there was evidence of allodynia and an increased pain response to cold some months after complete healing of the ulnar nerve and surgical wound.

The recent observations of Frost *et al.*‡ explain the hypersensitive response to cold. Frost's group found that patients with sympathetically maintained pain (RSDS) had cold hyperalgesia and signs of increased sympathetic tone. The thermographic studies of our patient confirmed the increased sympathetic tone in the ulnar nerve dermatome (fig. 1A). A persistent painful hypothermia of the fifth finger and lateral palm was reversed successfully with TDNP, which suppressed the sympathetic vasospastic (fig. 1B) cooling response. Frost *et al.* proposed that the increased sympathetic tone results in vasoconstriction and increased adrenergic sensitivity by the nociceptors. Another possible explanation is that primary afferent nociceptors become hypersensitive to cold, causing pain and stimulating sympathetic efferents, which in turn increase the nociceptor adrenergic sensitivity in a "positive-feedback loop."

Any conclusion about the efficacy of TDNP compared to that of sympathetic blockade is premature at this time. In addition to the conventional observations in RSDS, such as bone scans, radiographs, temperature changes, and digital arterial pressures, other parameters deserve attention. These include the objective studies of oxygen, carbon dioxide, *p*H, lactate, and pyruvate levels of the venous drainage in the affected extremity.

In summary, an unusual manifestation of segmental RSDS is presented and the results of TDNP are described. The favorable response to TDNP in our patient indicates that this therapeutic modality may be useful in segmental RSDS in the event that sympathetic nerve blocks are not feasible.

‡ Frost SA, Srinivasa N, Raja J, Campbell J, Meyer R, Khan A: Does hyperalgesia to cooling stimuli characterize patients with sympathetically maintained pain (reflex sympathetic dystrophy)?. Proceedings of 5th World Congress on Pain. New York, Elsevier, 17:151–156, 1988

References

1. Kozin F, McCarty DJ, Sims J, Genant H: The reflex sympathetic dystrophy syndrome: I. Clinical and histologic studies: Evidence for bilaterality, response corticosteroids and articular involvement. Am J Med 60:321–331, 1976
2. Kozin F, Genant HK, Bekerman C, McCarty DJ: The reflex sympathetic dystrophy syndrome: II. Roentgenographic and scintigraphic evidence of bilaterality and of periarticular accentuation. Am J Med 60:332–338, 1976
3. Smith DL, Campbell SM: Reflex sympathetic dystrophy syndrome: Diagnosis and management. West J Med 147:342–345, 1987
4. Steinbrocker O, Spitzer N, Friedman HH: The shoulder–hand syndrome in reflex dystrophy of the upper extremity. Ann Intern Med 29:22–52, 1948
5. Rosen PS, Graham W: The shoulder–hand syndrome: Historical review with observations on 73 patients. Can Med Assoc J 77: 86–91, 1957
6. Cremer S, Maynard F, Davidoff G: The reflex sympathetic dystrophy syndrome associated with traumatic myelopathy: Report of 5 cases. Pain 37:187–192, 1989
7. Ingram GJ: Reflex sympathetic dystrophy following nail biopsy. J Am Acad Dermatol 16:253–256, 1987
8. Helms C, O'Brien E, Katzberg R: Segmental reflex sympathetic dystrophy syndrome. Radiology 135:67–68, 1980
9. Tietjen R: Reflex sympathetic dystrophy of the knee. Clin Orthop 209:234–243, 1986
10. Chalkley JE, Lander C, Rowlingson JC: Probable reflex sympathetic dystrophy of the penis. Pain 25:223–225, 1986
11. Hyland WT: Treating reflex sympathetic dystrophy with transdermal nitroglycerin. Plast Reconstr Surg 83:195, 1989
12. Jones JW: Reversal of vascular spasm with nitroglycerin. Plast Reconstr Surg 81:302–303, 1989
13. Martin L, Foley BS, Schatz L: Topical nitroglycerin facilitates intravenous regional techniques in patients with RSDS. ANESTHESIOLOGY 69:1029, 1988
14. Hecker JF, Louis GPH, Stanley H: Nitroglycerin ointment as an aid to venepuncture. Lancet 1:332–333, 1983
15. Vaksmann G, Rey E, Vereviere GM, Smadja D, Dupuis C: Nitroglycerin ointment as an aid to venous cannulation in children: Clinical and laboratory observations. J Pediatr 3:89, 1987
16. Eskinder H, Gross GJ: Differential inhibition of alpha-1 *vs.* alpha-2 adrenoceptor-mediated responses in canine saphenous vein by nitroglycerin. J Pharmacol Exp Ther 238:515, 1986
17. Coppock JS, Hardman JM, Bacon PA, Woods KL, Kendall MJ: Objective relief of vasopasm by glyceryl trinitrate in secondary Raynaud's phenomenon. Postgrad Med J 62:15–18, 1986
18. Nielsen SL, Lassen NA: Measurement of digital blood pressure after local cooling. J Appl Physiol 43:907, 1977
19. Franks, Jr. AG: Topical glyceryl trinitrate as adjunctive treatment in Raynaud's disease. Lancet 9:76–77, 1982
20. Roberts WJ: A hypothesis on the physiological basis for causalgia and related pains. Pain 24:297–311, 1986