Use of Liquid-crystal Thermography to Evaluate Sympathetic Blocks

PEDRO M. DIAZ, M.D.*

SYMPATHETIC nerve blocks are frequently used in the treatment of vasospastic disease and as diagnostic tools for other peripheral vascular diseases. Frequently, it is difficult to determine the effectiveness of such blocks because objective criteria may be lacking. The methods suggested to test for efficacy objectively are qualitative or semiquantitative. In this catagory belong 1) venous dilatation, 2) the sympathogalvanic reflex,[1] 3) abolition of sweating demonstrated by the ninhydrin test,[2] 4) the comparison of skin temperatures in the blocked and unblocked extremities. The limitations of these tests are especially evident in those cases where circulation to the extremity is affected in a patchy distribution.

The ideal test for the evaluation of sympathetic nerve blocks should: 1) allow quantitative assessment of changes in the circulation to the whole area affected by the block, 2) be noninvasive, 3) be readily available, 4) be inexpensive. A method that appears to fulfill these criteria is liquid-crystal thermography. I have evaluated the use of thermography with cholesteric liquid crystals to assess the effectiveness of sympathetic nerve block of the upper extremity.

Liquid thermography has been used by others for location of the placenta and detection of breast cancer.[3,4] This technique produces color thermograms over a large skin area with a temperature sensitivity of 0.1 degree C and a spatial resolution of 1,000 lines per inch.[5,6] The method is inexpensive, noninvasive, safe, and the color change with temperature has a time constant of 0.1 seconds.[5]

Liquid crystals are compounds that have color–temperature sensitivity when in the cholesteric phase. The cholesteric phase is a state of matter with a molecular arrangement intermediate between a solid and a liquid. For some compounds, cholesteric phase exists in a specific temperature range; above and below this range, the compound exists as a liquid and as a crystalline solid, respectively. In the cholesteric phase the molecular arrangement produces maximal scattering of a specific wavelength of light and the other wavelengths are transmitted through the material. When viewed against a black background the scattered light shows an iridescent color and the transmitted light is absorbed by the black background. A small change in temperature alters the molecular order and changes the wavelength that is subject to maximal scattering. A given cholesteric liquid crystal always shows the same color at a given temperature. Many esters of cholesterol have these properties, and their color–temperature responses have been characterized so that a combination of esters can be used to measure temperatures from −20 to 250 C.

The materials used in these experiments are commercially available (as a kit) from Liquid Crystals Biosystems, Inc., 26101 Miles Ave., Cleveland, Ohio 44128. The kit consists of four aerosol cans containing crystals with ranges of 30–33 C, 31–34 C, 32–35 C and 33–36 C, and aerosol cans containing water-soluble black base, at a cost of $50.00. A conservative estimate is that there is enough material for 40 patients in each kit.

The coldest temperature of each range shows as red and orange and the warmest as blue and violet; intermediate temperatures show as yellow and green. Below and above the range the only color visible is that of the black base.

REPORT OF A CASE

A 55-year-old white man was admitted to the Veterans Administration Hospital, Miami, complaining of intermittent claudication and paresthesias in both feet and the left hand, of one month's duration. He had adult-onset diabetes mellitus of

* Associate Professor, University of Miami School of Medicine.

Received from the Veterans Administration Hospital, Miami, Florida 33136. Accepted for publication February 3, 1976. Presented in part at the Annual Meeting of the American Society of Anesthesiologists, Chicago, Illinois, October 1975.

Address reprint requests to Dr. Diaz.

FIG. 1. Angiogram of the left arm, showing complete occlusion of the ulnar artery close to its origin with reconstitution in the distal arm. The radial artery is markedly narrowed, with almost complete occlusion in the area of the wrist joint.

10 years' duration, apparently well controlled with diet. Four to five weeks prior to admission, the patient had experienced "pins and needles" and coldness in the left hand, which became worse. The fingers were very sensitive to cold, and were red and tender. The patient smoked two packs of cigarettes a day. On physical examination, the left hand was cold compared with the right hand and there was erythema of the third, fourth and fifth fingers on the left. There was a very tender, superficial ulceration of the tip of the left fifth finger. There were 2+/4 brachial and radial pulses in the right arm on palpation, and a 2+ ulnar pulse was detectable by Doppler ultrasound. Corresponding examinations of the left arm showed 2+ brachial and radial pulses and no ulnar pulse.

An angiogram of the left arm (fig. 1) showed normal subclavian, axillary and brachial arteries. The ulnar artery was completely occluded approximately 1 cm past its origin, with minor reconstitution in the distal arm. There was marked narrowing of the radial artery and its interosseous branches with almost complete occlusion in its distal portion close to the wrist joint. At this point small collaterals reconstituted a portion of the palmar arch. The circulation to the hand and wrist was markedly diminished. The Anesthesiology Department was consulted to determine whether there was a vasospastic component in the patient's disease that could be helped by sympathectomy.

METHODS

The left stellate ganglion was blocked on two separate occasions with 20 ml 0.25 per cent bupivacaine with epinephrine, 1:100,000, using the technique described by Moore.[7] Prior to administration of the block, the temperature of the forearm was determined with a skin thermometer probe (Yellow Springs Instrument Company). The oil in the skin was removed with a solution of 70 per cent ethyl alcohol, and the black base was sprayed on and allowed to dry. The 31–34 C crystals were then sprayed on and allowed to dry. Room temperature was kept at 20 C. After a 10-minute period for equilibration, control photographs (not shown) were taken, using Kodak Ektachrome film with electronic flash. The temperature range of the crystals was chosen so that the warmest areas prior to the sympathetic block corresponded to a blue color. A second set of pictures was taken 15 minutes after administration of the block.

RESULTS

Prior to stellate-ganglion block, skin temperatures, as measured by liquid-crystal thermography, were less than 31 C (black) in the third, fourth and fifth fingers; 34 C (blue) in the forearm and thumb; 31 C (red) in the second finger; 32–33 C (orange-green) in the distal portion of the palm, 33–34 C (blue-green) in the thenar eminence, and 33 C (green) in the hypothenar eminence. After stellate-ganglion block skin temperatures were more than 34 C (black) in the thumb, forearm, and thenar and hypothenar eminences; 34 C (blue) in the distal portion of the palm and second finger; 33–34 C (green-blue) in the proximal phalanges of the third,

fourth and fifth fingers, and less than 31 C (black) in the distal two phalanges of the second, third and fourth fingers. The patient reported subjective improvement after both blocks.

Comment

The arteriogram showed severe arterial occlusive disease of the left forearm and hand, with scant circulation to the third, fourth and fifth fingers. The liquid-crystal thermogram showed a vasospastic component in the forearm, palm, and first and second fingers, which was relieved by the sympathetic block. However, circulation to the distal two phalanges of the third, fourth and fifth fingers failed to improve after the sympathetic block.

The thermogram complements the arteriogram, indicating that the patient may be expected to benefit from surgical sympathectomy, with the exception of the third, fourth and fifth fingers.

The subjective improvement reported by the patient after the blocks indicates either a placebo effect or an increase in blood flow, sufficient to relieve the pain, that was not recorded by the thermogram. The 31–34 C range of the crystals precluded measurement of temperature increases below 31 C. That there was only a modest increase of circulation to the proximal phalanges of the three involved digits speaks against any increase in circulation to the distal phalanges.

The thermogram provided quantitative information about the extent of circulatory improvement obtained at every point in the hand. Thus, it proved to be a better tool in assessing the results of sympathetic block than any of the other available tests. Liquid-crystal thermography is a simple, inexpensive and readily available technique that increases the accuracy of sympathetic block as a diagnostic–prognostic test in peripheral vascular disease.

Informed consent was obtained for this procedure after full explanation to the patient. This study was approved by the Human Experimentation Committee of the Miami Veterans' Administration Hospital.

References

1. Lewis LW: Evaluation of sympathetic activity following chemical or surgical sympathectomy. Anesth Analg (Cleve) 34:334–345, 1955
2. Dhumer KG, Edshage S, Wilhelm A: Ninhydrin test—an objective method for testing local anesthetic drugs. Acta Anaesthesiol Scand 4: 189–198, 1960
3. Davison TW, Ewing KL, Sayat N, et al: Liquid crystal thermographic placental location. Obstet Gynecol 42:574–580, 1973
4. Davison TW, Ewing KL, Fergason J, et al: Detection of Breast cancer by liquid crystal thermography. Cancer 29:1123–1132, 1972
5. Fergason JL: Liquid crystals in non-destructive testing. Appl Optics 7:1729–1739, 1968
6. Crissey CT, Gordy E, Fergason JL, et al: A new technique for the demonstration of skin temperature patterns. J Invest Dermatol 43: 89–92, 1964
7. Moore DC: Regional Block. Fourth edition. Springfield, Ill., Charles C Thomas, 1965, pp 123–137

Severe Hyperthyroidism Associated with Hydatidiform Mole

Jong Min Kim, M.D.,* Kasumi Arakawa, M.D.,† Vicki McCann, R.N.‡

In 1955, Tisne and associates reported three cases of hydatidiform mole associated with clinical hyperthyroidism that disappeared within a few days after delivery of the mole.[1] Since that time, similar cases with increasingly sophisticated hormonal studies have been reported.

Three different normal thyroid stimulators, *i.e.*, pituitary thyrotropin, chorionic thyrotropin, and long-acting thyroid stimulator (LATS) have been described. Kenimer and associates[2] reported that when human chorionic gonadotropin activity fell below 150–170 units/ml, thyroid-stimulating activity was undetectable, and they calculated human chorionic gonado-

* Assistant Professor of Anesthesiology.
† Associate Professor of Anesthesiology.
‡ Nurse Anesthetist.
Received from the Department of Anesthesiology, University of Kansas Medical Center, Kansas City, Kansas 66103. Accepted for publication February 3, 1976.