TECHNICAL NOTE

Quantitative thermography 'in arthritis using the AGA integrator

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Inflammation produces increased heat in the affected tissues of the body. In rheumatoid arthritis, a rapid increase in temperature occurs in the affected joints during acute inflammatory stages of the disease. Thereafter changes in temperature may be used as a measure of the disease process and the effect of treatment. Infra red thermography can be used as an objective measure of a patient's response to anti-inflammatory drugs.

Many circulation problems have been investigated by thermography, and it is clear that the technique when quantitated can be used to measure the affects of certain drugs which act on circulation, e.g. vasodilators.

For evaluating the effects of certain drug therapies, serial colour thermograms, can be used to demonstrate any changes in temperature. The appreciation of the degree and rate of change must be subjective. A numerical index can, if carefully standardised, provide an objective score for measurement and comparisons of clinical change. Furthermore, better understanding of technique and variability arises from numerical indeces, when statistical analyses are applied.

A method for quantitating thermograms was published by Collins et al in 1974 [1, 2, 5]. The isotherms from a selected area of the picture were measured and expressed as a thermographic index. This figure was based on a temperature range with defined upper and lower limits. Normal joints on cooling at 20°C fell to 26°C or below, and few hot joints exceeded 32 or 34°C. The index scale ranges from 1.00 to 6.00. This system has been in use at Bath for over three years and some 20,000 estimations made. The effects of oral non-steroid, parenteral steroid and cytotoxic agents have been successfully quantitated by this method. The treatment of Paget's disease of bone with Calcitonin[3], and of vasospastic conditions with nicotinate derivatives have also been shown[4]. The process of quantitation is simplified by interfacing a pdp8 minicomputer to the thermograph. The image is analysed from a secondary colour monitor interacting with the computer system.

Recently, a new device has been tested, which can under certain conditions, provide the basic facilities for calculating the thermographic index.

The unit is described as the AGA 100 integrator, and is designed as an optional accessory to the AGA 680 Thermovision. Connection to the monitor of the 680 Thermovision superimposes one or two brightline rectangles on the display. The size and x-y location of the rectangles is adjustable, the former with 5 x 5 preset positions, and the latter continuously variable. Thus the region of interest may be positioned in any part of the display, but will be of reproducible size and shape (Fig. 1).

The number (video value) is displayed which is an expression of the average (integrated) radiant energy from one of two rectangular areas selected from the field of view. This

number is shown as a percentage of a preset maximum level, with adjustable zero and 100% levels.

This paper describes the simple tests applied to this system used in parallel with the proven computer unit, to correlate the integrator values with the thermographic index.

The video value can be read independently from channel 1 or channel 2. The difference between channel values can be displayed and the maximum video values expressed sepalately from each channel or box.

CALIBRATION

The Thermovision 680 was set up before an AGA 1010 Reference Source with the monitor set at 10°C and midscale calibration at

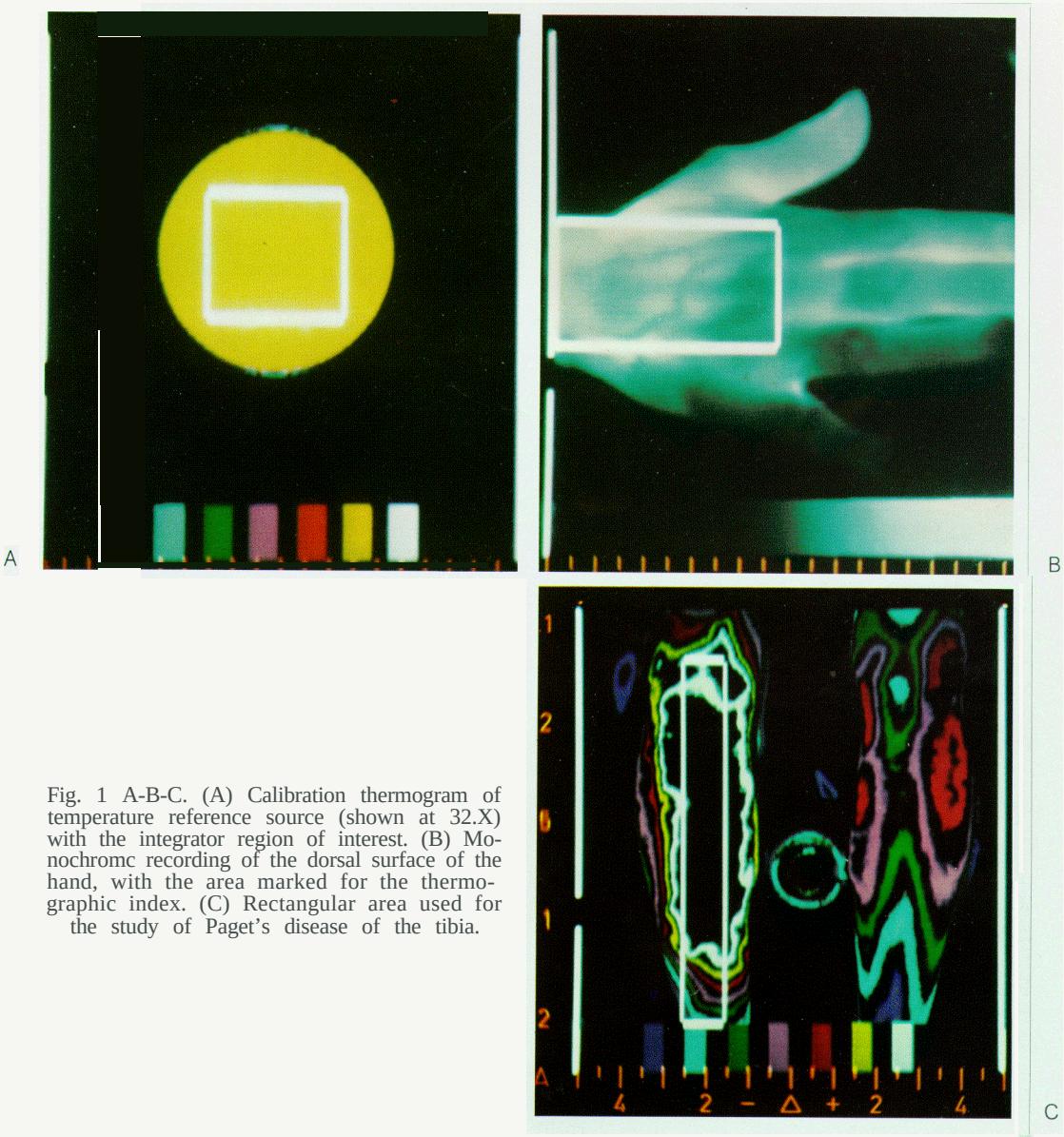
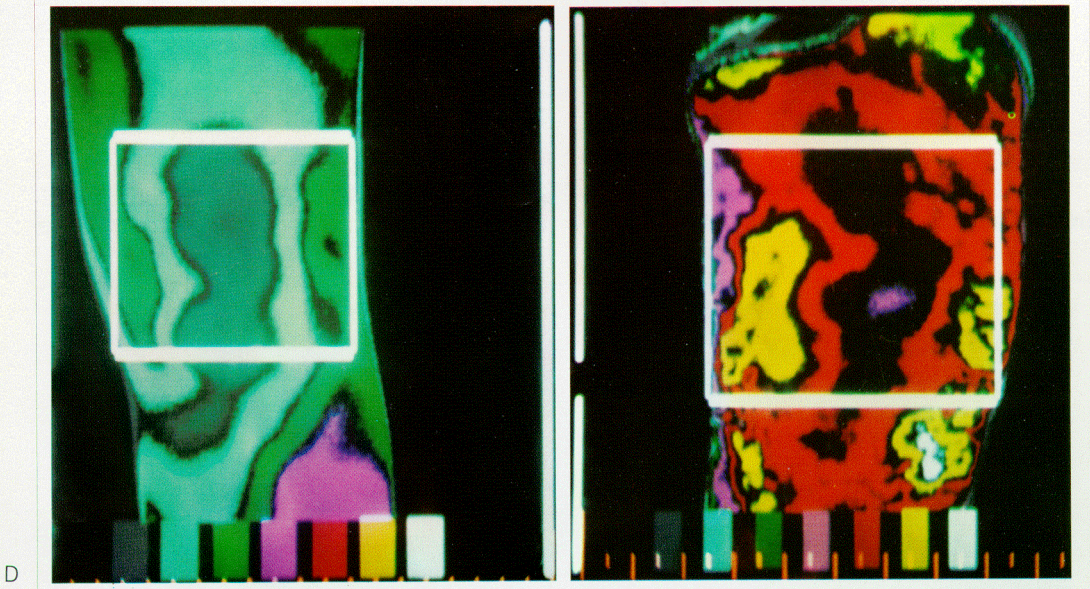


Fig. 1 A-B-C. (A) Calibration thermogram of temperature reference source (shown at 32.X) with the integrator region of interest. (B) Monochromc recording of the dorsal surface of the hand, with the area marked for the thermographic index. (C) Rectangular area used for the study of Paget's disease of the tibia.



Pig. 1 D-E. (D) Anterior knee thermogram with marked area - normal joint; T. index 1.9. (E) as D - Rheumatoid arthritis; T. index 5.1.

31°C. The image of the reference source at 26°C (ambient 20°C) was positioned to occupy not less than half the total screen area, and one box located off the centre of the image (Fig. 1A). Zero adjustment was made on the **integrator** panel, and checked with an isotherm (at -5 Monitor scale). The reference was then readjusted to 36°C and the integrator set to 100%. To produce comparable normal **values** in the t.index for hands and tibiae, a baseline temperature of 28 °C is used (Ring 1976). These values may be achieved by subtracting 20 from the meter reading of the integrator.

STANDARD VIEWS

Tiselius 1969 described a series of standard positions for thermographic recording of joints. Ring 1975 based the calculation of the thermographic index on a square of rectangular regions selected from standard views.

Hands - a rectangle placed over the dorsal surface from the ulnar prominance

(a) at the wrist to finger clefts, to include the metacarpal joints.

(b) rectangle placed over fingers 1-3 (excluding thumb and little finger) from finger cleft to nail bed, with the three fingers closed.

Knees Anterior - square area placed over centre of patella with margins *within* the edges of the image (patient standing).

Lateral - square placed over the centre of the joint, which is in 90° flexion (patient seated).

Elbows Lateral - square placed over joint with area in 90° flexion held against a board as heat shield.

Ankles Lateral - square area centred over malleolus with toe-heel pointing vertically (patient seated with foot on a stool).

Backs - rectangular area centred over spine from lumbar to sacral, and wide enough to include the sacro iliac joints.

Tibia Anterior - narrow rectangle from tibia1 head to 2 cm above malleolus. Patient sitting with legs vertical and parallel facing thermograph.

The Integrator was used with the AGA 680 Thermovision in the same room as the Bofors Mk. 3 Camera, interfaced to a pdp8e computer. A scan was made by both systems within 2 minutes of each standard position for the pa-

tient under examination. The thermographic index was calculated by the computer from an area of interest selected from a 64 x 64 matrix of the processed image. The AGA Thermovision unit was positioned at a fixed distance from the patient, and the index from the digital scale of the integrator noted.

Thirty joints examined this way produced values which were within 10%. Twenty four joint indices showed less than 5% difference. Examples of the thermograms and the index are given in Fig. 1B - 1E.

APPLICATIONS

The effect of a drug which can affect surface temperature i.e. an anti inflammatory steroid preparation can be monitored by infra red thermography.

The daily change in temperature distribution may be difficult to assess from colour isothermograms. However, a numerical index showing a small but continuing change increases the validity of the method. The thermographic index has been used to study the dose and time related effects of differing steroid compounds, when injected into arthritic knees. One patient was successfully monitored over a period of 12 days following an injection of Triamcinolone Hexacetonide into the knee. Both infra red systems were used together on each occasion, and the fall in T.index following steroid, and its subsequent increase again 13 days later was shown (Fig. 2).

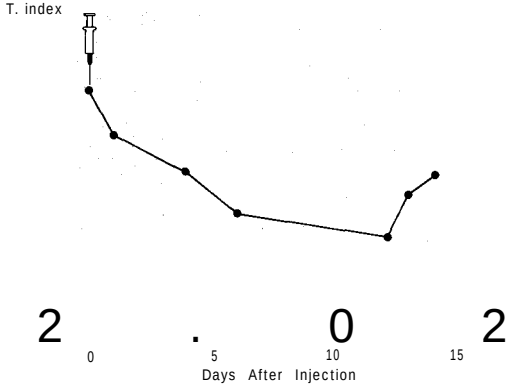


Fig. 2. The fall in thermographic index of the knee from a patient with active rheumatoid arthritis, following a single injection of Triamcinolone Hexacetonide, 50 mg. This « long acting » preparation was shown to produce optimal anti-inflammatory effect in this patient in' the second week after injection, returning towards the pre-injection state at 15 days.

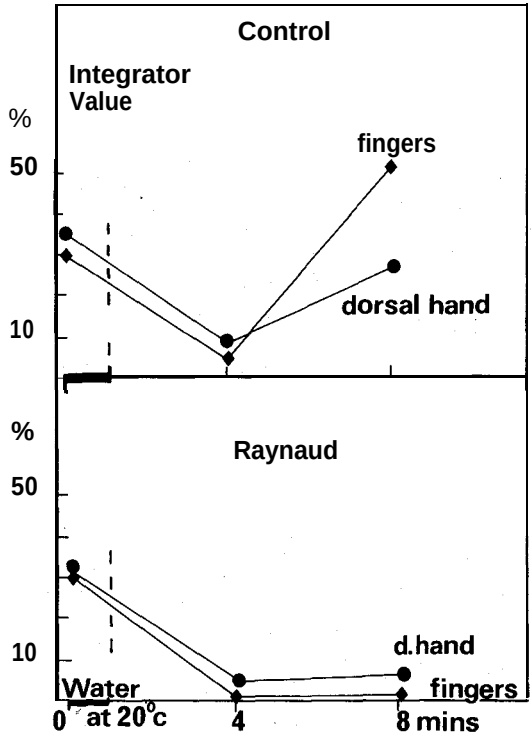


Fig. 3. The response to mild cooling (20°C) of a normal (A) and Kaynaud (B) hand recorded by the AGA Integrator. The dorsal hand values (•) are recorded as in 1B and the fingers (◆) by a similar region of interest measured over the four fingers held together. In the normal hand hyperaemia is shown by rapid recovery of the fingers and in excess of the precooling value.

More immediate changes in temperature can be demonstrated by thermography. Stimulation and hyperaemia tests can be applied, and a numerical index used to quantify the reaction. A dynamic hyperaemia test applied to a normal subject, and one with Raynaud's phenomena, illustrates the clear difference in under 10 minutes. The hyperaemia is induced by immersion in water (in a thin plastic glove) at 20°C for 60 seconds, in normal subjects. A number of such tests can be used, to evaluate vasospasticity and the effects of vasodilatory or B blocking agents on peripheral circulation (Fig. 3).

A numerical index also provides immediate

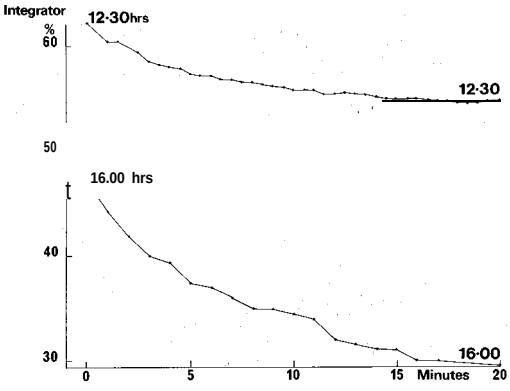


Fig. 4. The effect of cooling a normal knee joint in a room at 20°C at 12.30 hrs. and 16.00 hrs. on the same day, illustrating diurnal variation.

data for graphical recording of the physiological state of the body. Greater understanding is needed in areas of fundamental physiology. The effects of circadian rhythm and environment on skin temperature will be more efficiently explored by quantitative thermography. Joint temperature expressed as thermographic index fluctuates during the 24 hour cycle. Readings are lower and more stable in the morning, and a peak is usually seen around midday. The fall in T.index of the knee was recorded from a normal subject immediately entering the thermography room and during a 20 minute cooling period. The rate of cooling is shown in Fig. 4, both at 12.30 and at 1600 hours. This graph illustrates the practical value of serial quantitative measurements.

CONCLUSIONS

The Aga Integrator is a useful accessory to the AGA 680 thermographic system. It provides a basic form of quantitation from a given range of rectangular samples, which may be easily positioned over an area of interest in the thermogram. Preliminary studies have shown that care is needed in the setting up of the instrument. However, proper alignment and standardised technique will enable the instrument to be used for reliable quantitation of thermograms. The thermographic index, of proven value in the study of rheumatic diseases, is also applicable to other studies of peripheral areas of the body. By suitable calibration, values are obtainable from the inte-, grator which parallel this index. It should, therefore, be of particular value in the quantitation of inflammatory and vascular diseases and the response to treatment of drugs, surgery or therapy.

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