Closing lecture

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The place of thermography in medicine

Thermography is an excellent method of examination useful in many fields of which the majority of our medical colleagues are ignorant. Its place at the moment is in the novelty section of medical investigation and general medical opinion in that it is a jet aged entity not to be taken seriously. Partly because of this it is being used by a few enthusiasts and is in danger of remaining in this situation and not coming into general use.

It has been said about thermography that it will not succeed unless it can give an answer to a problem that no other method can. Though this is not correct there is an element of truth, in that the best method of, as it were, selling thermography to our colleagues and thus ensuring its general acceptance is by highlighting the things that it can do which cannot be done by other methods. If we do not do this then thermography will fail in that it will remain an investigation used by a few enthusiasts. It is also important at the same time to point out the advantages of thermography as a form of investigation. When this education has taken place the other uses of thermography will be accepted. The advantages are worth reiterating and they are:

1) **Complete safety.** The investigation is passive. There is no necessity to touch the area being examined, in fact it is contra-indicated. Since there is no interference with the patient no harm can be done.

2) Lack **of pain.** There are not many investigations where some discomfort is not experienced. This must be taken as an advantage.

3) Lack of invasiveness. This is of course conducive to more accuracy and is more reassuring for the patient.

4) Safe and easy reproducibility. This is essential in a scientific investigation especially if it is sequential. The fact that this is now possible and also with the introduction of standardisation, thermography must be taken more seriously scientifically for too many papers have been written on clinical impression. This should no longer occur. Hard scientific proof of the efficacy of thermography has to be presented to make it generally acceptable.

5) Low running costs. In these hard times this must be an advantage. Generally the impression is that thermography is expensive, an impression which must be corrected. Once the initial cost of the equipment is met, only the liquid nitrogen and the film are ongoing expenses. Bearing these factors in mind, if thermography can give as good results as other methods of investigation of a problem, then thermography is the method of choice and our colleagues must realise this.

The argument that is being developed is that since we have a valuable diagnostic tool in our hands we must make sure it comes into common use.

It is worth looking at thermography in the four different contexts in which it is used. They are:

1. As an adjunct to another procedure which increases the accuracy of both.
2. As the investigation of choice where it is superior to any other method. This is the area in which more work should be done to help to establish thermography.
3. As a prognostic guide.
4. As a measure of the efficacy of some form of treatment.

A) THERMOGRAPHY AS AN ADJUNCT

The field which is best known in association with thermography is breast cancer and its importance is in no doubt but it is this field that has caused the acceptance of thermography to be delayed. The reason for this is that as thermography has developed both technically and as a diagnostic tool the premature hope for it as the answer to the early diagnosis of breast cancer has gradually faded so that now we are in the present position of knowing that it is too inaccurate to be used by itself and, in fact, it is only to be used to make the results of mammography better. In spite of this most thermography meet-

ings are still hopelessly overweighted in presenting this aspect of thermography. Many medical men hoped that thermography would be the early warning system which would improve the mortality figures for breast cancer which have remained virtually static for thirty years. When this did not occur they unfairly assumed that thermography was of equally limited use in other fields. This, of course, is not true. In spite of it not being able to give the necessary early diagnosis there are various facts which it supplies which are useful.

We know that a patient with a suspicious thermogram is ten times more likely to develop cancer than the normal. It allows us therefore to find high risk patients and study them in conjunction with mammography which gives the best chance of early diagnosis and therefore better prognosis. Young women on the pill with nodular breasts can be followed adequately with thermography alone by taking a thermographic base line which normally changes very little. However, thermography basically can only be used with mammography. If we wish to further the cause of this science less emphasis must be placed on breast cancer and more on other spheres.

A similar situation with thermography as an adjunct exists in the study of solitary nodules in the thyroid. A nodule, if it is cystic, has little risk of cancer and can therefore be left alone or aspirated, thus avoiding surger. However, if the nodule is solid it should be removed surgically because of the risk of cancer. The use of thermography with ultrasound enables differentiation of these nodules. The results of thermography and ultrasound by themselves are reasonably good but if the diagnosis is the same using both methods the results are almost 100% correct. This use is valuable as the diagnosis previously was by radioactive iodine with not very good results. Using these systems in conjunction unnecessary operations can be avoided.

In the study of secondary bone cancers thermography by itself has an 87% true finding rate and gives a more accurate indication of the extent of the disease than normal X-ray and sometimes gives an earlier diagnosis in the lumbar region. In conjunction with isotope studies better accuracy and earlier diagnosis are brought about. Thus we see that thermography plus another investigation can be of great value but when thermography can suply the answer to a problem by itself it must be more impressive and leads people to appreciate its worth. Therefore it is important that more notice is taken of and more work done on these methods of choice.

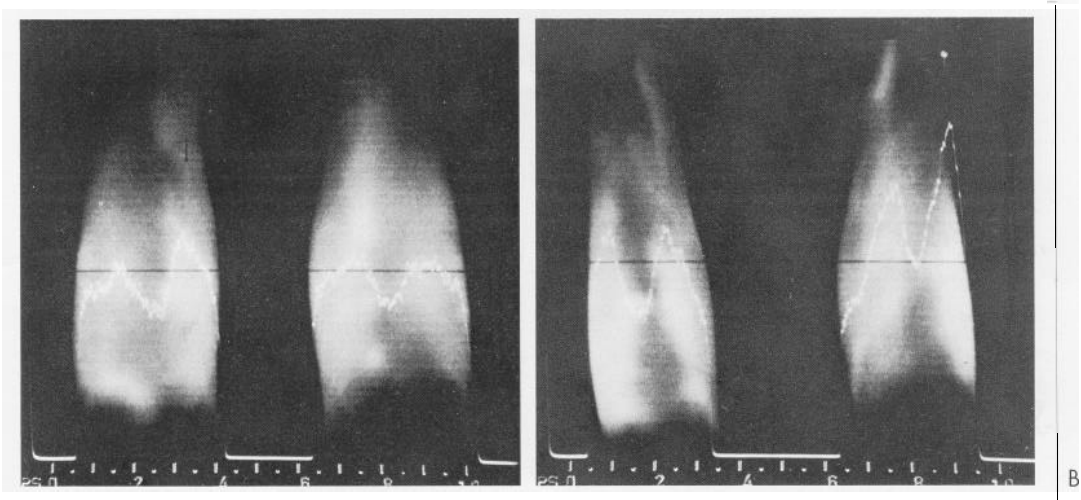


Fig. 1. A) A normal supine thermograph of both calves before exercise with typical thermo-profile across the central calf. The skin overlying the subcutaneous tibia is cooler (darker) than the skin overlying the calf on either side. B) After-exercise pattern shows accentuation of the pre-tibia1 cooling seen in the normal resting pattern.

B) THERMOGRAPHY AS A METHOD OF CHOICE

1) Burns. In the modern treatment of burns, deep and deep partial thickness burns are excised and the area grafted so the diagnosis of the depth

of burns has become increasingly important. This can be very difficult and there are over twenty known methods possible, none of which is simple, so clinical estimation is almost always used. A full thickness burn is 2.5°C colder than comparable skin and a deep dermal is 1.5' colder, so it can be seen which areas of a burn should be excised and which areas left. This reduces the amount of surgery required and early diagnosis enables surgery to be performed before sepsis intervenes as well as preventing unnecessary surgery in partial thickness burnes. Over 300 burned areas have been studied using thermography and compared with the clinical impression of burns experts; thermography was shown to be three times more accurate and must therefore be the method of choice.

2) Deep vein thrombosis. Mortality is increasing in tbrombo-embolic disease, therefore we need early diagnosis and effective prophylaxis. Cooke and Pilcher have shown that raised temperature and delayed cooling on exposure of the thrombosed limb is an early sign of deep venous thrombosis which can be detected thermographically when not apparent clinically. In a series of 53 thromboses detected by phlebography, 51 had been previously suspected thermographically. In the same **series** 56% of the cases were not diagnosed on clinical examination. Similar results were obtained by Henderson et al., when comparing thermography with radioactive fibrinogen. Henderson also points out the great potential of the post exercise test in high risk patients (Fig. 1 A-B; Fig. 2 A-B).

Here is a field where because of the advantages of thermography it would appear to be the investigation of choice. The mortality from D.V.T. is high and if we are to use thermography to save life then there is surely more scope here than in cancer of the breast. It would appear that if the true worth of thermography in medicine is to be appreciated more work should be done in spheres such as this.

3) Testing the viability of flaps either traumatic or planned.

In plastic surgery when a flap is raised it is left for three weeks to permit adequate circulation to be acquired by the flap. It is then divided and usually succeeds. Thermography is a simple way of seeing if the flap is ready to move before three weeks or if it should be delayed at three weeks as it would fail if divided. Weeks of hospital care can be saved using this method which is the one of choice, as there is no other effective and simple method available. Similarly traumatic flaps are often raised in accidents and sewn back

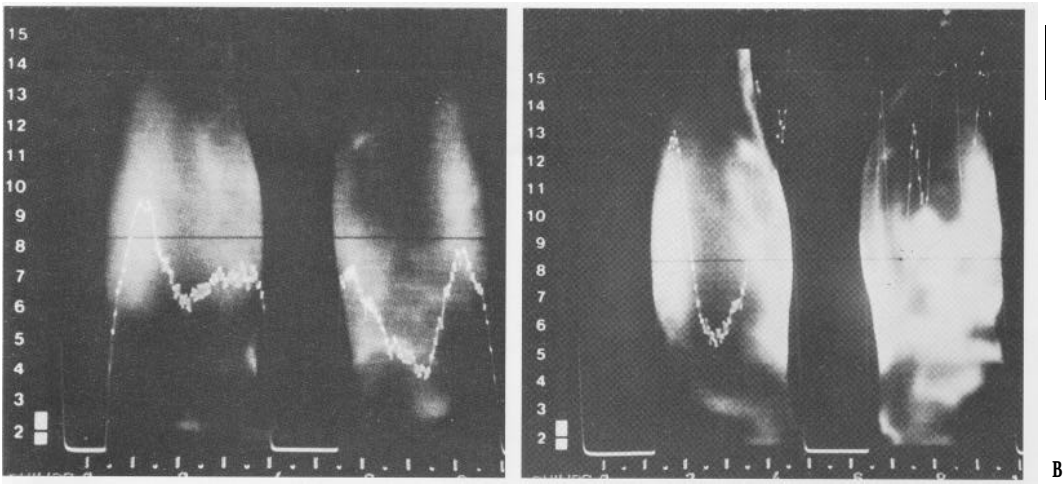


Fig. 2. A) A normal resting thermograph of both calves. B) An abnormal after-exercise pattern showing -dilated veins over the pre-tibia1 area more marked in the left calf (on the right of the picture) than in the right calf (on the left of the picture). This thermographic image is obtained by a mirror suspended over the patient hence inversion of left and right. This patient sustained a bilateral deep vein thrombosis. There is a more than two-fold increased incidence of deep vein thrombosis in a calf showing an abnormal after-exercise pattern.

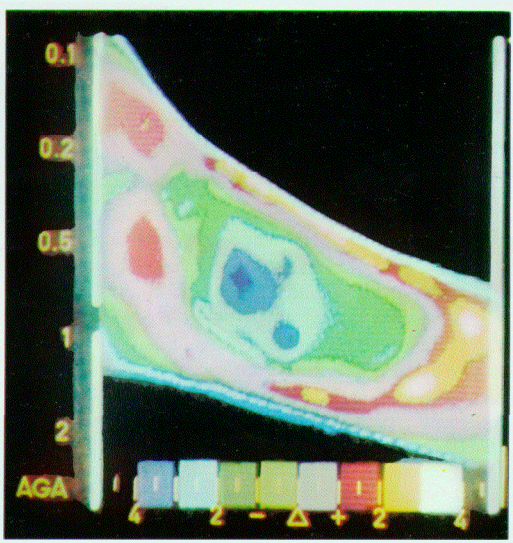
in the hope that they are viable. It is a considerable time before they are found not to be and have to be excised and the area grafted. This wasted time can be avoided by thermography (Fig. 3 A-B-C-).

4) Malignant melanoma. Spitalier's work in diagnosing malignant change in melanotic lesion5 using thermography is associated with a prognostic index depending on the increase in temperature and the presence or absence of a flare. Malignant melanoma is still bedevilled by ignorance as to the best form of treatment but any improvement in diagnosis especially without any physical interference must be a useful step forward in this vicious disease. The most reliable method is excision biopsy but if this must be done the necessity to remove large areas of tissue is still in doubt, frozen section is often unreliable and large lesion5 and lesions on the face present special problems. An 80% chance of the correct diagnosis as given by thermography preoperatively makes this method the screening test of choice.

4) Amputation sites. In an arteriosclerotic patient it is important to be sure that if an amputation of the lower limb is intended, if possible a below-knee amputation is performed because of more high incidence of re-operation occurs and this is because no scientific assessment of the site of amputation has been made because there is no mobility, lighter prostheses and the 30% chance of becoming a bilateral amputee. The assessment is usually done clinically but with the use of thermography more certainty of success of the operation can bc obtained. The main factor for success is the viability of the skin flaps and this can be measured. In many amputation series a simple one available. If a busy clinician is dealing with a common entity, which amputation is, he will only use scientific tests if they arc simple and quick. The simplest and quickest for assessment of the amputation site is thermography. If its value can be demonstrated to surgeons performing these operations it will come into common use.

5) Localisation of perforating varicose veins. Patel's work ha5 shown how little difference there is between phlebography and thermography in this very common field. With the advantage5 of thermography over phlebography, i.e. lack of invasiveness and no irradiation, thermography is the better method. In this sphere a5 in many other5 the commonest diagnostic test is the purely clinical one which will show up gross clinical defects

Fig. 3. A) Persiatent ulcer of malleolus to be treated with free flap and microvascular anastomosis. B) Immediatelv post-operatively. C) Thermograph showing marked temperature loss over free flap which was a complete failure.



but not the less obvious. If clinicians are to be persuaded to use a scientific method in a common condition it must be reliable, safe, and simple, which thermography is.

6) Carcinoma of the larynx. Recent work has suggested that the time required to wait for surgery following irradiation of the larynx can be estimated using thermography. Since no other method is available this must again be the method of choice.

7) **Microvascular surgery.** This is a speciality which growing very quickly and has many possibilities. At the moment it is used manly in the reimplantation of severed digits and hands and in the free transfer of pieces of tissue instead of using flaps. The success of surgery has to be monitored very carefully because if thrombosis occurs the anastomosis must be treated surgically without delay otherwise the tissue supplied dies. Baudet of Bordeaux who is one of the leading experts of this kind of surgery maintains that thermography is the best monitoring system to warn of the necessity for further surgery and also as a prognostic guide. He maintains that if replantation of a digit is fully successful (arterial and venous drainage perfectly re-established) and the temperature recorded on the second or the third post-operative day is either normal or more often 2°C lower than the contralateral healthy finger. By the first week the temperature reaches normal values. Sometimes a hyperthermia is observed.

If replantation shows complications thermography provides useful data in the first post-operative day. In the event of arterial thrombosis with complete devascularisation the temperature drops quickly after the occurrence of the complication and this temperature drop reached 8 to 10°C compared with the contralateral healthy finger. In the event of venous embarrassment the temperature drop may be 4°C or slightly more. If the temperature drop reaches the value of 6°C this proves that no tissue survival can be expected.

If the replantation is complicated by arterial or venous problems but is not followed by complete failure of the replantation (this failure usually occurs in the first four days) a thermogram at the end of the-first week gives interesting data on the extent of tissue survival that can be expected. Thermography is also interesting in crushing injuries of the hand and in several instances a thermogram done earlv after the iniurv has shown that no finger survival was to be expected while the clinical examination was questionable.

Thus we see thermography being used in a brand new exciting field as a method of choice and probably this is virtually unknown.

C) THERMOGRAPHY AS A PROGNOSTIC GUIDE

Microvascular surgery has been mentioned and it is also useful in ordinary arterial surgery as it is one of the best indications of perfusion of tissues. In malignant melanoma, Spitalier has shown the significance of a thermographic flare and its use as an indicator of a liability to breast cancer is well known.

D) THERMOGRAPHY AS A MEASURE OF EFFICACY OF TREATMENT

Of more significance is its use as an index of the efficacy of treatment in several conditions. Rheumatoid arthritis is a good example of this and Ring's work in this field on the use of the therapeutic index based on a multi isothermal analysis of a joint area permits thermography to tell not only if a method of treatment is effective but how effective. This quantitative aspect is an invaluable advance and must improve the chances of thermography being taken seriously if more people know of it and more work is done which it.

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The possibilities for the use of thermography in medicine are numerous - a few have been mentioned but many have not. It is still a comparatively unexplored field in which the potential will not be fully realised unless it comes into more common use. The heartening events which are likely to help here are the standardisation of the use of thermographic equipment and the formation of more thermographic societies. The former would mean that all investigations anywhere are comparable and thus higher scientific standards could be achieved. The latter would help to stimulate advances in thermography and also, more importantly at the moment, educate the medical masess in the use of thermography.