Thermographic Diagnosis of Deep Venous Thrombosis[1]

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Two hundred patients with suspected deep venous thrombosis had thermography performed prior to ascending phlebography. Diagnostic agreement was obtained in 79%. Published diagnostic thermographic criteria were used; it was not possible to diagnose consistently limited or early thrombosis, especially in the calf muscle veins. Venous insufficiency produced the majority of false positives.

INDEX TERMS: Extremities,thrombosis • Thermography • Thombosis, venous • (Vascular system, venous thrombosis, 9.751) • (Veins of lower limb, thrombosis, 9[3].751) • (Vascular system, thermography, 9.129)

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USING THERMOGRAPHY to diagnose deep venous thrombosis was suggested in 1972 by Soulen *et al.* (1). They confirmed that thermography was helpful in recognizing the increased heat emission associated with thrombosis, but considered that the thermographic features were nonspecific and that thrombosis could not confidently be differentiated from inflammatory diseases in the leg. Diagnostic criteria were subsequently introduced and successfully applied by Cooke and Pilcher (2, 3), and further studies using those criteria have been published which confirmed the accuracy of thermography (4–6). We have attempted to evaluate the usefulness of thermography as a diagnostic screening modality in all patients with suspected deep venous thrombosis of the lower limb referred for ascending phlebography.

MATERIALS AND METHODS

Two-hundred patients referred to the Radiology Department of Temple University Hospital between May 1976 and June 1977 were examined by thermography immediately prior to ascending phlebography. Forty-four of these patients were subjects in a prospective hip surgery protocol and had both ^{125}I-fibrinogen uptake tests and phlebography performed routinely in the postoperative period.

A standard AGA 680 medical thermographic unit was used, which consists of a scanning camera, mirror, and display unit, and produces images with a high thermal resolution (greater than 0.2° C at 30°C). Images were recorded on polaroid film. Patients were exposed from the waist down with the legs externally rotated and elevated to more than 10° above the horizontal to avoid venous pooling. Thermal equilibrium was allowed to occur over ten minutes prior to examination. Whenever possible, the patients were also examined in the prone position. The diagnostic criteria used were those described by Cooke and Pilcher in 1974 (3). The thermograms were interpreted prior to phlebography. Results in disagreement were reviewed retrospectively.

TABLE I: COMPARISON OF THERMOGRAPHIC AND PHLEBOGRAPHIC FINDINGS

		Thermogram +	Thermogram −
Phlebogram	+	53	19
	−	26	113
Total			211

Ascending phlebography was performed using a modified method and diagnostic criteria described by Rabinov and Paulin (7). We obtained 211 phlebograms in 200 patients.

RESULTS

A comparison of the thermographic interpretation with the phlebographic findings is presented in TABLE I. The overall incidence of positive phlebograms was 34% (72/211). There was diagnostic agreement between thermography and phlebography in 79% (166/211). The false-negative rate for thermography was 26% (19/72) and the false-positive rate, 19% (26/139). In our population this gave a predictive value of a positive thermogram of 67% and that of a negative thermogram of 86%.

Of the 44 patients who also had ^{125}I fibrinogen uptake tests, 26 had positive tests at the time of ascending phlebography. The presence of thrombosis was confirmed by phlebography in 22 of these patients and of this group, 7 had negative thermograms. Two patients with negative fibrinogen tests had positive thermograms, and in 1 of these, thrombosis was confirmed by the phlebogram.

The false-positive and false-negative thermograms were analyzed retrospectively (TABLE II). The phlebograms in

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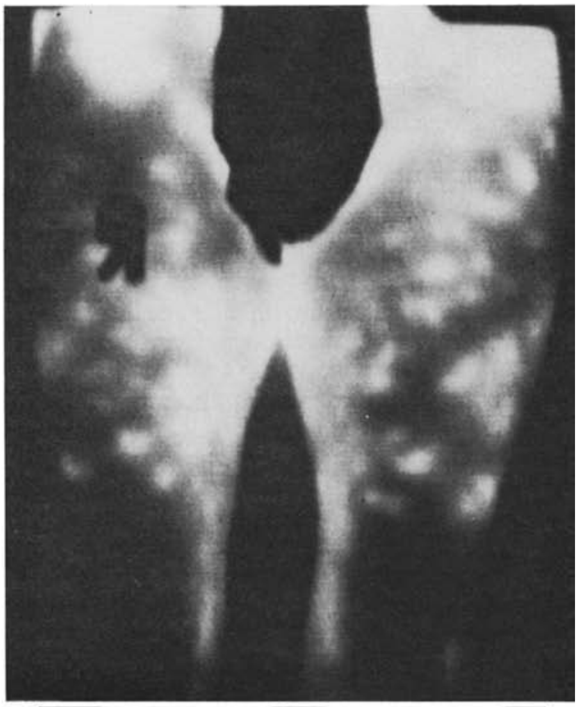

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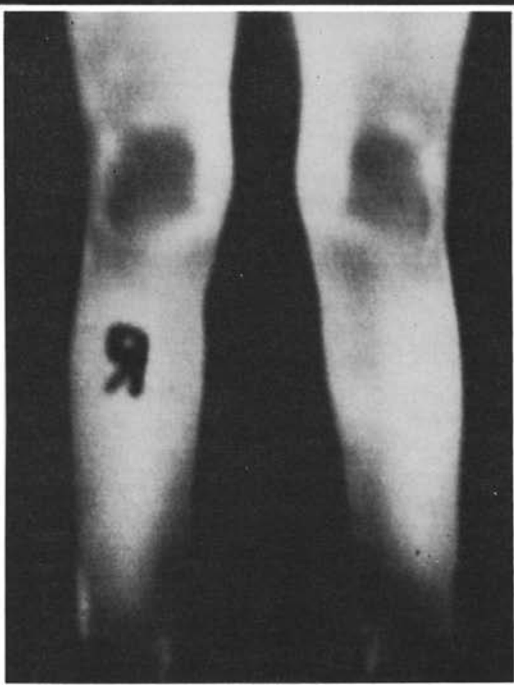

Fig. 1a. Thermogram of normal thighs shows mottled pattern.
b. Thermogram of normal knees and calves demonstrates a uniform pattern of heat emission, with areas of coolness in the pretibial and prepatellar areas.

the false negatives demonstrated that in 7 patients there had been evidence of thrombosis of indeterminate age. Exclusion of these 7 patients reduced the false-negative rate from 26% (17/72) to 18% (12/65) and improved the predictive value for a negative thermogram to 91%.

All of the remaining 12 patients had evidence of recent thrombus, with distinct filling defects seen within the opacified veins. Only 1 patient had extensive calf vein thrombosis with involvement of the popliteal vein. This patient's thermogram was technically poor and, when repeated, showed changes typical of thrombosis. The remaining 11 patients had very limited thrombosis. In 9 there was involvement of soleal sinuses, and in 3 of these there was short segmental involvement of other deep veins of the calf. In 2 patients there were short, nonocclusive thrombi in the common femoral vein. Phlebographically, these were not associated with evidence of collateral flow in the superficial veins.

TABLE II: ANALYSIS OF THERMOGRAPHIC INTERPRETATIVE ERRORS

False negatives (total 19)		
Old thrombosis		7
Current thrombosis by site		12
Extensive calf	1	
Soleal sinus	6	
Soleal sinus with calf veins	3	
Nonoccluding femoral veins	2	
False positives (total 26)		
Inflammatory disease–cellulitis		4
Edema in CHF		3
Lymphedema		1
Venous insufficiency		18

The causes for the 26 false-positive thermograms were also reviewed. There were 4 patients with extensive inflammatory disease involving the lower leg, 3 patients with asymmetric leg edema related to resolving congestive heart failure, and 1 patient with unilateral lymphedema. The remaining patients were considered to have venous insufficiency and, while the majority of these showed extensive superficial filling of varicose veins on phlebography, several patients only showed filling of relatively normal-sized superficial veins in larger numbers than is usually associated with a normal study. The patients with unilateral leg edema and lymphedema also showed deviation of blood from deep to superficial veins.

DISCUSSION

The normal thermogram of the lower limb demonstrates a smooth gradation of heat emission down the legs, with the thighs about 4° C warmer than the feet. There are well defined areas of coolness in the prepatellar and pretibial areas (Fig. 1). A frequently encountered normal variation is a mottled skin-heat-emission pattern noted especially in the thighs but occasionally in the calves of obese females. Involvement of the calf by thrombosis is associated with a diffuse area of increased heat emission involving all or most of the calf in the supine anterior view. This is associated with loss of the pretibial coolness (Fig. 2). With extension of the thrombosis to the popliteal vein there is increased heat emission on the medial side of the knee and lower thigh, with loss of the prepatellar coolness. Involvement of the thigh is associated with a diffuse area of increased temperature in that region.

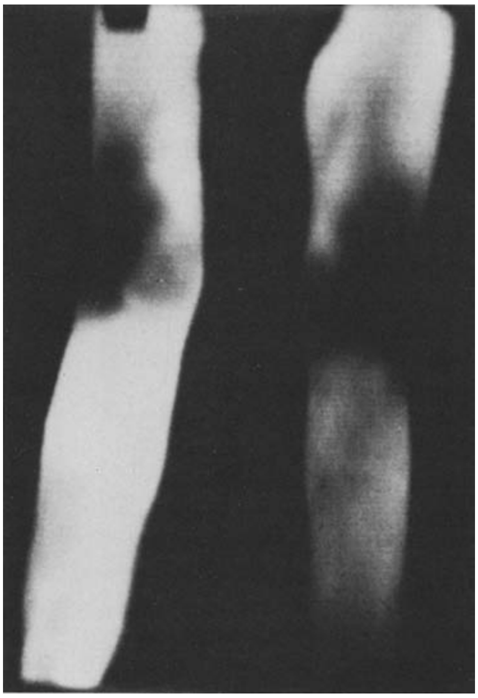

Fig. 2. Deep venous thrombosis of the right leg. There is increased heat emission from the calf with loss of pretibial coolness and lateral shift of prepatellar coolness.

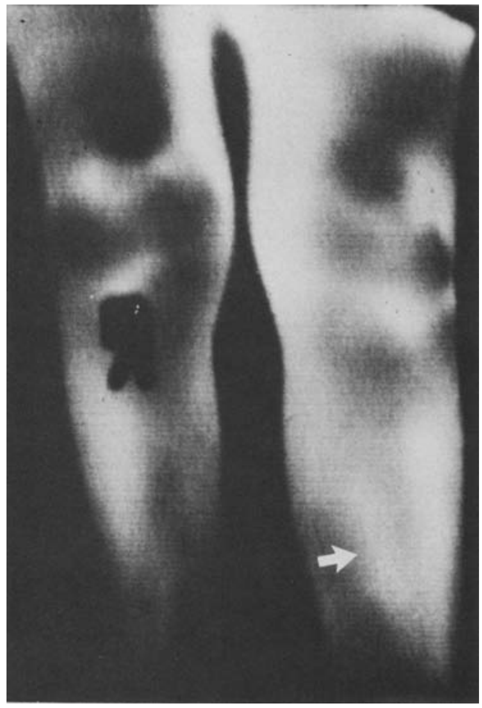

Fig. 3. Soleal vein thrombosis of the left leg. A small area of increased heat emission (arrow) in the mid-calf. Increased heat emission from both knees is related to osteoarthritis.

In our study we were unable to reproduce the results of previous investigators. We obtained diagnostic agreement in only 79%, compared with 96% by Cooke and Pilcher (3), 94% by Bergqvist *et al.* (5), and 90% by Bystrom *et al.* (4). However, the data of the previous investigators are based on prevalence rates of thrombosis of 52%, 72%, and 51%, respectively, whereas our prevalence rate was 34%. This in itself would diminish the predictive value of a positive thermogram in our population. However, our population differed in a more fundamental way, in that there was a higher incidence of early thrombosis referred for phlebography because of the widespread use of the ^{125}I fibrinogen uptake test. Furthermore, there was a high prevalence of venous insufficiency and old venous thrombosis in our population. These two factors accounted for the major areas of disagreement in our study. The greatest limitation in our study was the inability to recognize thrombosis which was limited to one or two of the deep veins of the calf. Bergqvist *et al.* (5) also failed to recognize limited calf vein thrombosis. In the remaining published studies, we found no comment pertaining to this limited thrombosis, which suggests that thrombosis was extensive at the time of the diagnosis. In particular, 22 of the 26 cases of deep vein thrombosis diagnosed by Bystrom *et al.* (4) involved the calf and femoral veins and were thus extensive.

Review of the thermograms of patients with isolated soleal vein thrombosis revealed definite abnormalities in 5 (Fig. 3). These abnormalities consisted of subtle areas of increased heat emission on the medial aspect of the midcalf. The significance of these findings was not appreciated at the time, and they were not considered to fulfill the diagnostic criteria outlined by Cooke and Pilcher (3). Because these patients had undergone hip surgery before examination, they were not examined in the prone position, which in our experience is of value in confirming early thrombosis in the calf. It is also of interest to note that the majority of these patients were referred because of positive ^{125}I fibrinogen uptake tests, reflecting the ability of this modality to recognize early deep venous thrombosis. We feel that failure to demonstrate limited or early thrombosis in the calf in our series was related to inadequate diagnostic criteria and failure or inability to examine the patient in the prone position, which may be an important limitation in such a high-risk group. However, recognition of early thrombosis would also be assisted by serial examination in hospitalized patients. Cooke (8) has studied hip-surgery patients in this way and has demonstrated the development of deep venous thrombosis with a high level of accuracy.

The other unsatisfactory feature in our series was the high false-positive rate (19%), in part due to the inclusion of cases of venous insufficiency which may produce a hot thermogram. Venous insufficiency can, however, often be differentiated from thrombosis through enhancement of the superficial venous pattern, using the middle temperature-range control. This allows appreciation of the background "muscle-mass" temperature which in the

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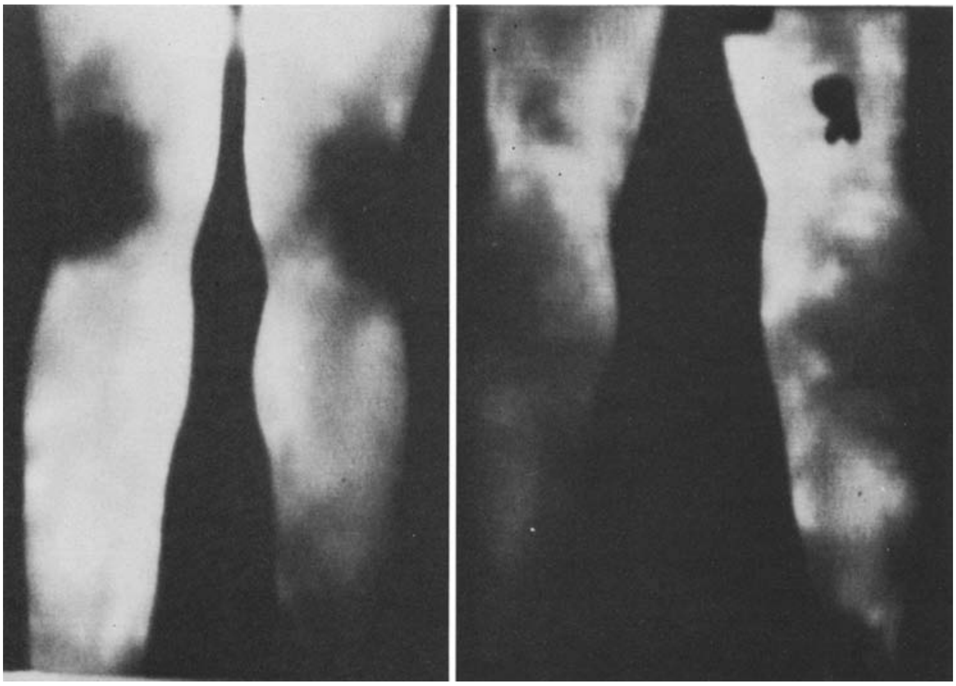

Fig. 4a. Venous insufficiency of the right leg. The anterior view shows poorly defined areas of increased heat emission with probable normal background limb temperature.
b. The posterior view shows similar changes and confirms that the background limb temperature is normal, thus excluding the possibility of deep venous thrombosis.

absence of thrombosis should not be significantly raised (Fig. 4). This background temperature is elevated with thrombosis, and the superficial venous pattern, while still apparent, is only minimally more prominent. Comparison with the contralateral leg is helpful in such situations. Appreciation of these features allowed us to reduce our level of false positives from 29% in the first 100 patients to 10% in the second 100. Nevertheless, the subtle signs of thrombosis are more difficult to recognize in patients with venous insufficiency and, since these patients have an increased incidence of thrombosis (especially when immobilized), it may be impossible to exclude the presence of early or limited thrombosis with a high degree of confidence.

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