Use of thermography in the diagnosis of deep vein thrombosis

THOMAS W. FREE, DO
GEORGE O. FAERBER, DO

We attempted to evaluate the use of liquid crystal thermography (LCT) as a screening tool in the detection of deep venous thrombosis (DVT) in the lower extremities. Forty patients were examined with LCT and venography. A venogram was used as the standard by which the LCT results were compared. Liquid crystal thermography had a sensitivity of 70% and a specificity of 50%, and it was found *not* to have a greater accuracy than clinical examination.

The diagnosis of deep vein thrombosis (DVT) in the lower extremities is difficult to impossible to make on clinical grounds alone. The use of edema, Homan's sign, palpable tenderness, and palpable warmth as well as patient history as indicators frequently will lead to an inaccurate diagnosis.

The lower extremity venogram is the most accurate method of detecting DVT, and it is indeed the gold standard. Venography, however, is a somewhat invasive technique. It requires that a foot vein be cannulated, which frequently is impossible in patients with considerable edema. Pain is a frequent complaint. An iodine contrast agent must be used to opacify the veins. Such an agent cannot be used in patients with an allergy to iodine unless the patient has been prepared with corticosteroids and antihistamines. The contrast agent can produce an allergic reaction in patients without a known history of allergy. Iodine contrast itself can predispose to DVT. Venography also requires the use of radiation, which would be best to avoid if the diagnosis could be made by other means.

In this study, we attempted to evaluate the use of thermography in the diagnosis of DVT. Sandler

and Martin¹ have reported that thermography is 96.7% sensitive in detecting DVT.

The theory behind the possibility of using thermography as a means to diagnose DVT is the following: Thermography would be more sensitive and more objective than palpation as an indicator of temperature differences. A thrombus can produce an increase in temperature that is detectable at the skin surface by at least two mechanisms: the first is through the local inflammation caused by the thrombus itself; the second, through the increase in superficial venous flow of blood caused by an obstruction within the deep venous system.

Methods

Liquid crystal thermography involves the use of cholestearic crystals impregnated in sheets of latex. The crystals respond to different temperatures by changing color. The latex sheet (detector surface) is mounted on one side of a box measuring 28 × 36 cm. A transparent viewing window forms the other side of the box. Air can be introduced into the box to produce a convex surface on the detector surface. When the detector is brought into contact with the target area, the flexibility of the membrane allows the detector to conform to the anatomy.

Eight thermographic detectors are available, with mean temperature sensitivities of 24°, 26°, 28°, 29°, 30°, 31°, 32°, and 33°C, respectively. Each detector has a range of temperature sensitivity of 4° to 5°C. The colors on the detector for coolest to warmest temperature, range from brown to tan, yellow, green, blue-green, and blue.

The detector box is mounted on a metal frame. The frame has a camera mounted on the side opposite the detector so that once the maximal color change for the detector has occurred, an instant

Figure 1. Thermograms of anterior aspect of thigh (top) and calf (bottom) of a patient suspected of having DVT of left leg (on the reader's right). Left leg does not show increased warmth with respect to right leg. There is no evidence of DVT by thermography.

Figure 2. Venogram of left leg of patient in Fig 1. There is complete absence of deep venous system in thigh and calf secondary to DVT.

photographic print can be made to record the results.

A brief history is obtained from each patient. The patient is then examined for Homan's sign, edema, palpable tenderness, and palpable warmth.

In preparation for the thermographic study, the patient lies on the table with his or her heels elevated about 10 degrees to reduce superficial venous pooling. All clothing is removed from the upper thigh down. After the patient has remained in this position for about 2 minutes, a thermographic detector is selected whose mean temperature sensitivity matches the mean temperature of the part of the anatomy to be examined. First, with the patient in the supine position, the anterior aspect of the thighs and calves are examined. Next, the posterior aspect of the thighs and calves are examined. Then, with the patient in the prone position, the posterior aspect of the thighs and calves are examined. After the four areas of interest have been examined, the leg in which thrombus is suspected is compared with the normal leg. If the temperature of the leg with the suspected thrombus is higher, the thermogram is regarded as positive.

After a thermogram has been obtained for each patient, venography is performed. The venogram is used as a standard of comparison for the results of the thermogram. The thermogram is read by a radiologist who does not know the venography results.

Results

A total of 40 patients were studied. Venograms showed that 10 patients had DVT and that 30 had normal deep veins. The findings for Homan's sign, edema, palpable tenderness, and palpable warmth and the thermographic results were compared with venographic results.

Among the ten patients with venography-proved DVT, 6 (60%) had a positive Homan's sign, 7 (70%) had edema, 8 (80%) had palpable tenderness, and 6 (60%) had palpable warmth. The thermogram was positive in seven (70%) of the cases of DVT. Three cases were falsely negative as assessed by thermography.

Figure 3. Venogram of left leg of patient with DVT present in femoral and popliteal veins with extension into smaller veins of the calf. On the thermograms of posterior aspect of thigh and calf, there did not appear to be a significant difference in the warmth of legs. There was no evidence of DVT by thermography.

Figure 4. Thermograms of anterior aspect of thigh and calf of a patient suspected of having DVT of the right leg (on the reader's left). Leg warmth is symmetric bilaterally. There is no evidence of DVT.

Figure 5. Venogram of right leg of patient in Fig 4. There is evidence of DVT in a few of the deep veins of calf.

Among the 30 patients with negative venograms, 21 (70%) had a negative Homan's sign, 20 (67%) had no edema, 12 (40%) had no palpable tenderness, and 18 (60%) had no palpable warmth. Thermography was negative in 15 (50%) of these patients.

The results are summarized in the Table.

Discussion

Signs and symptoms of DVT include tenderness, pain, warmth, and edema. A patient with DVT may

have any or all of these signs and symptoms. In this study, we evaluated the effectiveness of thermography as a screening tool in predicting unilateral DVT of the lower extremities. We found thermography to have a sensitivity of 70% and a specificity of 50%.

The low specificity of thermography can be explained by the fact that conditions other than DVT can produce increased warmth in the leg. These include recent surgery, recent fracture, local infection, superficial varicose veins, and acute arthri-

Table
Effectiveness of Thermography Compared With Venography and Clinical Signs and Symptoms
for Detecting Deep Vein Thrombosis (DVT) (N = 40)

Venogram results	Results of other indicators	Homan's Sign No. (%)	Edema No. (%)	Palpable tenderness No. (%)	Palpable warmth No. (%)	Thermography No. (%)
10 positives (with DVT)	True positive	6 (60)	7 (70)	8 (80)	6 (60)	7 (70)
	False-negative	4 (40)	3 (30)	2 (20)	4 (40)	3 (30)
Total		10 (100)	10 (100)	10 (100)	10 (100)	10 (100)
30 Normal (without DVT)	False-positive	9 (30)	10 (33)	18 (60)	12 (40)	15 (50)
	True negative	21 (70)	20 (67)	12 (40)	18 (60)	15 (50)
Total		30 (100)	30 (100)	30 (100)	30 (100)	30 (100)

tis. To detect DVT in patients in whom these conditions are present, it always will be necessary to perform venography.

The sensitivity of thermography is no greater than that of the clinical evaluation, as seen in the Table. Palpable tenderness has a sensitivity of 80%; and edema, of 70%. Palpable warmth was concordant with the thermography in 90% (36) of the patients. In the four discordant cases, thermography was positive, and palpable warmth was negative. Deep vein thrombosis was present in only one of these four patients. These findings suggest that in detecting DVT, the greater temperature sensitivity of thermography offers no advantage over palpable increased warmth.

Figures 1 through 5 illustrate the sensitivity of thermography compared with venography. Venograms for the three patients in whom DVT was not detected by thermography are shown in Figures 2, 3, and 5. Thermograms converted to black and white for publication purposes are shown in Figures 1 and 4. In one patient, DVT was present just below the knee; but in the other two, DVT was extensive, involving the popliteal and femoral veins of the calf. Thus, DVT, even when it is extensive, is not always accompanied by increased warmth.

Conclusion

The study was somewhat limited by the relatively small number of patients (40). Thermography was shown to have a specificity of 50%. It was normal in three cases (30%) of DVT, two in which DVT was extensive and one in which it was limited to the calf. We therefore conclude that as a screening procedure, thermography appears to have little value.

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From the department of radiology, Doctors Hospital, Columbus, Ohio.

Reprint requests to Dr Free, department of neuroradiology, Henry Ford Hospital, 2799 W Grand Blvd, Detroit, 48202.