Radionuclide Venography: Correlation with Contrast Venography

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Radionuclide venography and contrast venography were performed in 47 limbs of 35 patients, and the findings were compared with respect to their location and characteristics. Positive radionuclide venogram findings were area of decreased radioactivity flow corresponding to the region of thrombosis, abnormal collateral flows, and radioactivity stasis below the lesion. A delayed clearance of radioactivity alone in the calf did not indicate venous thrombosis. The overall concordance between radionuclide venography and contrast venography was 89%. The result indicates that radionuclide venography, while technically simple, is a reliable test for the detection of venous thrombosis in patients with signs and symptoms of deep-vein thrombosis.

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Contrast venography (CV) is well accepted as the most reliable method for detecting deep-vein thrombosis. It requires a skilled medical team, however, and it can cause such complications as pain, local sepsis, and thrombophlebitis due to the contrast medium (*1,2*). Frequently the procedure has to be canceled because of difficulty with injection in patients with swollen legs or in patients allergic to the contrast medium. Contrast venography, therefore, is not recommended for routine use.

As the incidence of thromboembolic disease in hospitalized patients is surprisingly high (*3–5*), there is an urgent need for an accurate, simple, and noninvasive technique to detect venous thrombosis. When the radioiodinated fibrinogen test was introduced, it appeared to provide an ideal method for detecting deep-vein thrombosis. Encouraging results were published by many workers, and correlation between the test and contrast venography ranged from 83% to 100% (*6–8*). More recent studies with labeled fibrinogen, however, show that the false-negative rate can be 50% or higher with fresh thrombi (*9,10*). The actual counting for the test may be performed daily up to 10 days with one injection (*11,12*). The results over the pelvis and upper thigh are difficult to interpret because of high background activity (*13*).

Radionuclide venography with Tc-99m-labeled protein particles was introduced in 1969 by Webber et al. (*14*) as a simple and reliable method for detecting thrombophlebitis. Further observations were made by Rosenthall and Greyson in 1970 (*15*). The advantages of this method are as follows:

1. It is technically simple and can be performed in conjunction with the perfusion lung scan.
2. Concurrent images of inferior vena cava, iliac veins, femoral veins, and calf veins can be obtained with a single injection.
3. No significant complications from this procedure have been reported.
4. It is suitable as a screening test for hospitalized patients or outpatients.
5. The procedure takes less than 30 min, and results are available immediately.

The reliability of radionuclide venography (RNV) in detection of venous thrombosis has repeatedly been claimed to be excellent (*16–18*). Earlier studies, however, showed considerable discrepancy between the findings of radionuclide and contrast veno-

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TABLE 1. CORRELATION BETWEEN CONTRAST VENOGRAM AND RADIONUCLIDE VENOGRAM

		Contrast venogram	
		Positive	Negative
Radionuclide venogram	Positive* (26 studies)	16 (62%)	10 (38%)†
	Negative (21 studies)	2 (10%)	19 (90%)
Total	47	18	29

* Simple retention of radioactivity in calf region interpreted as positive finding.
† Seven with stasis in the calf; two with stasis and collaterals; one with collaterals only.

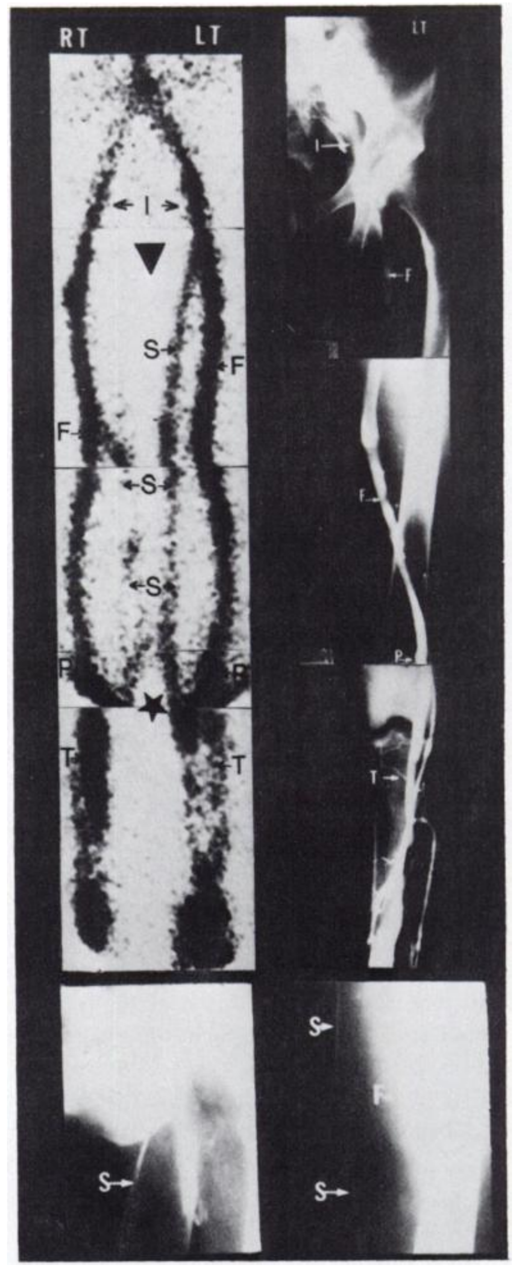

FIG. 1. Examples of normal bilateral radionuclide venogram (left) and normal left leg contrast venogram (right). Contrast venogram over upper thigh (lower) is overexposed in order to visualize saphenous vein. All pictures were composed of serial images. (▼) Pubic symphysis; (F) femoral vein; (P) popliteal vein; (★) knee joint; (I) iliac vein; (S) saphenous vein; (T) posterior tibial vein.

grams at the site of thrombosis or the calf-vein abnormality (*15,19*). In contrast with many published reports, a recent in vivo and in vitro study on radionuclide venography revealed that RNV hot spots did not represent thrombus, but corresponded instead to stasis below the obstruction (*20*). The mechanism for positive findings in radionuclide venograms remains controversial. In order to elucidate further the mechanism and reliability of RNV, we performed CV and RNV in patients and compared the findings.

PATIENTS AND METHODS

Forty-seven studies with each procedure were performed in 35 patients, 31 of whom had clinical signs or symptoms of thrombophlebitis. In one patient the studies were performed to evaluate a previously installed inferior vena cava umbrella, and in three patients they were done to locate the source of recurrent multiple pulmonary emboli. The interval between contrast venography and radionuclide venography was less than 48 hr. In 26 patients radionuclide venography was performed first, and in 9 patients the order was reversed.

Radionuclide venography. With the patient lying supine on an imaging table, two tourniquets were applied to each leg, one above the ankle and the other below the knee. Both lower legs were aligned in the field of the camera,* either one with a large field of view with parallel collimator or a conventional camera (11.5 in. field) with diverging collimator. A 2-mCi dose of ^{99m}Tc-macroaggregated albumin was injected into the dorsal vein of each foot.

When radioactivity flow through the calf veins was visualized on a persistance scope, the tourniquet over the ankle was released. Then images of the calf veins, femoral veins, and iliac veins were obtained consecutively. Immediately after the pelvic view, the thighs were again placed in the camera field and the tourniquets below the knee were released simultaneously with activation of the camera. Serial scintigrams of the thighs and pelvis were obtained. Finally, additional images of both lower legs were obtained. When areas of radioactivity retention in the lower legs were detected, the patient was instructed to exercise the lower legs, and repeat views were obtained.

Contrast venography. The patient was placed in a supine position on an imaging table, and two tourniquets were applied to each leg, one above the ankle and the other above the knee. Contrast medium† (50 ml, warmed to 37°C) was injected rapidly into a dorsal vein of the foot.

After two images of the lower leg were taken, the tourniquets were released and images of the thigh and pelvis were obtained. Frequently a second injection of contrast medium was required in order to obtain good images of the pelvic veins.

RESULTS

The radionuclide and contrast venographic findings were analyzed with respect to the characteristics and the specific location of the abnormalities.

Initially we interpreted stasis of radioactivity in the calf, persisting after leg exercise, as a positive finding. On this basis, 26 radionuclide venograms indicated the presence of thrombosis (Table 1), but in only 16 studies did contrast venography confirm the positive findings. Delayed clearance of radioactivity from the calf accounted for seven of the 10 false-positive findings. Contrast venography showed valvular insufficiency in two of the seven (Fig. 1), but the other five contrast venograms indicated no abnormality in the area of radionuclide stasis (Fig. 2).

Contrast venography was performed before radionuclide venography in two of seven studies that showed persistent stasis of radioactivity in the calf. Incompetent valves were seen on contrast venography in one of these two studies. It appeared, therefore, that preceding contrast venography was not the cause of false-positive findings on the calf.

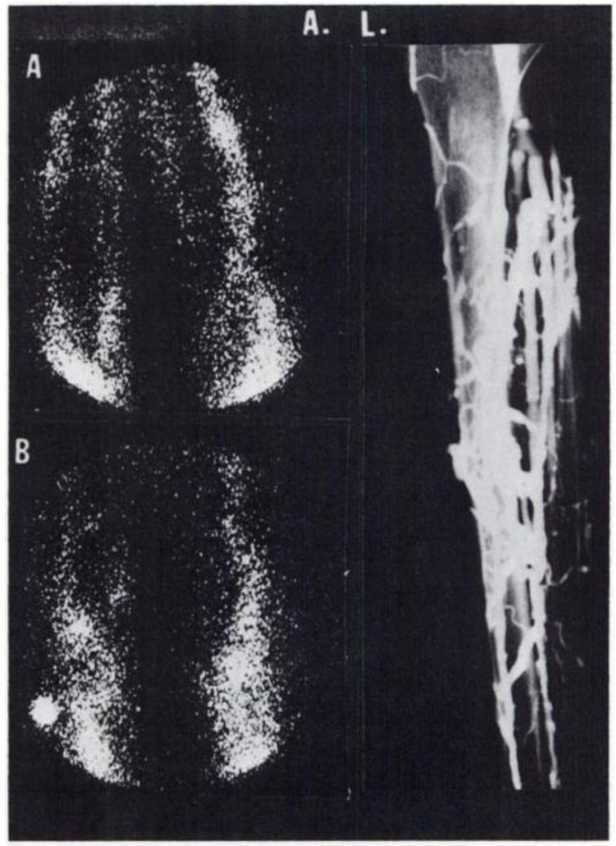

FIG. 2. Serial radionuclide venograms, early (A) and late (B), show retention of radioactivity in both calves. Contrast venogram from patient's left leg shows valvular insufficiency in posterior tibial vein.

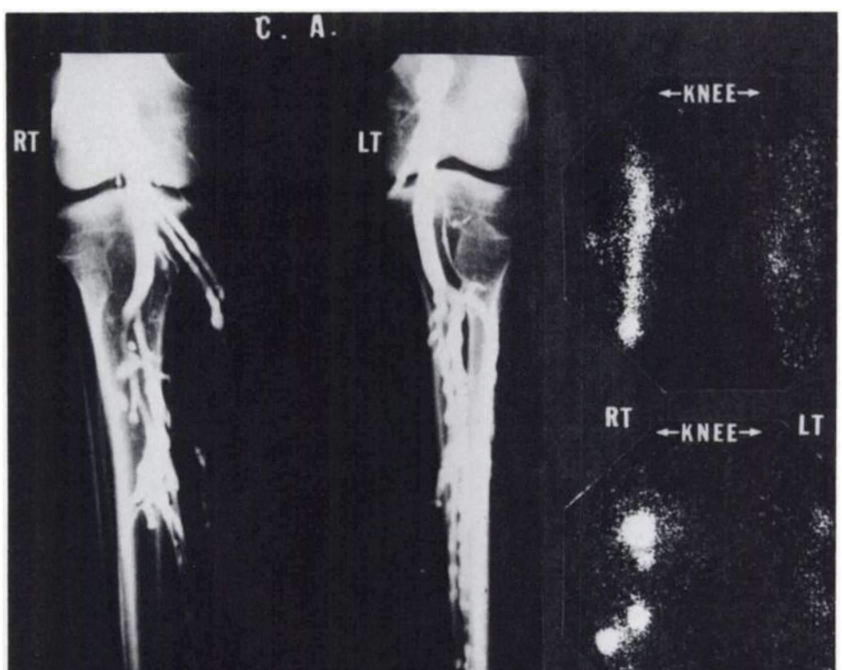

FIG. 3. Initial and 1-hr-delayed radionuclide venograms show marked retention of radioactivity in right calf and minimum retention in left calf. Contrast venograms show no abnormality in either calf.

Among the 16 studies in which both the radionuclide venogram and the contrast venogram were positive for thrombosis, at least two of the following findings were seen on the radionuclide venogram: (A) region of decreased radioactivity flow; (B) abnormal collateral flow; (C) stasis of radioactivity distal to the thrombosed region (Figs. 3 and 4 and Table 2). Retention of radioactivity was never seen as the sole finding. It thus became obvious that stasis alone does not signify deep-venous thrombosis, and we re-evaluated the results, classifying simple retention of radioactivity as a neutral finding.

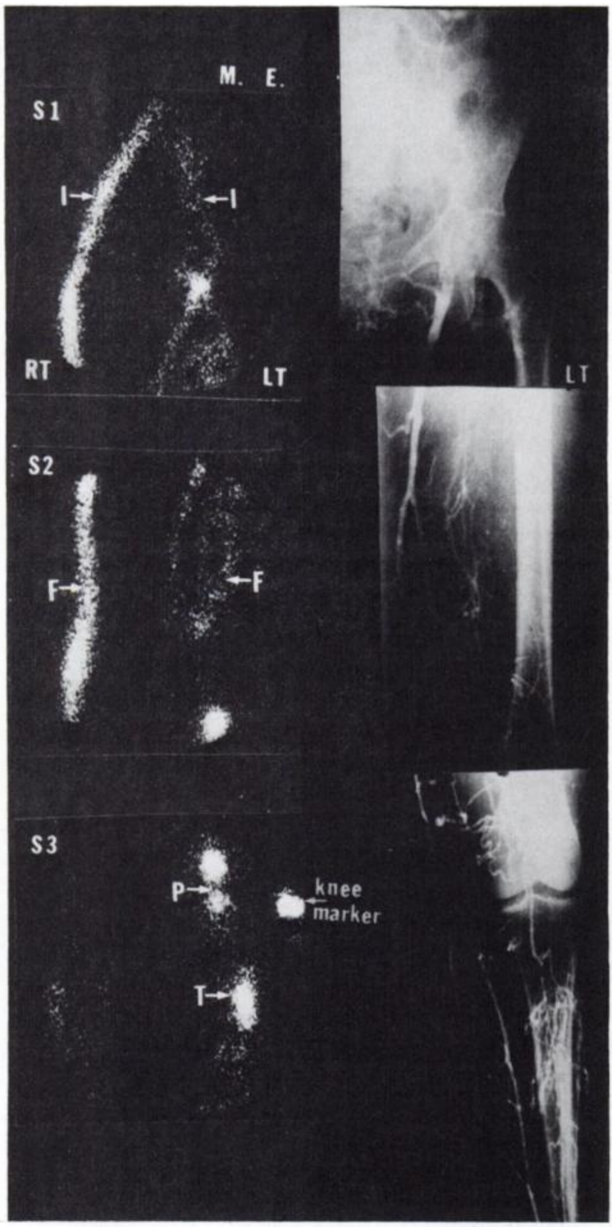

FIG. 4. Serial radionuclide venograms from iliac (S1), femoral (S2), and calf regions (S3) show no abnormality in the right leg. Venograms from left are markedly abnormal with areas of decreased flow, collaterals, and stasis of radioactivity. Contrast venograms from left leg show extensive thrombosis extending from iliac vein down to calf veins. (Landmarks are same as in Fig. 1.)

TABLE 2. CORRELATION OF FINDINGS BETWEEN CONTRAST VENOGRAMS AND RADIONUCLIDE VENOGRAMS

Radionuclide venography	Contrast venography
Persistently cold area 16	Thrombosis* 16
Collateral flows 19	Abnormal veins 16 Normal branches 3
Persistently hot area 26	Stasis below the lesion 16 Incompetent valve 4 Normal valve 6

* Includes two cases of extrinsic compression.

TABLE 3. CORRECTED CORRELATION* BETWEEN RESULTS FROM RADIONUCLIDE VENOGRAPHY AND CONTRAST VENOGRAPHY

		Contrast venogram	
		Positive	Negative
Radionuclide venogram	Positive (19 studies)	16 (84%)	3 (16%)
	Negative (28 studies)	2 (7%)	26 (93%)
Total	47	18	29

Accuracy 89%, sensitivity 84%, specificity 93%.
* Simple retention of radioactivity in calf region reclassified as neutral finding.

Table 3 shows the corrected results: 19 radionuclide venograms indicated the presence of thrombosis, and 16 (85%) contrast venograms concurred: 28 radionuclide venograms showed no thrombosis, and 26 (93%) contrast venograms concurred.

Radionuclide findings in the three false-positive studies included one case of stasis and collateral flow in the calf, one case of stasis and probable collateral flow in the iliac region, and one case of multiple abnormal collateral flows in the thigh. In the last case the contrast venogram revealed an unusual variation: triple femoral veins (Fig. 5) (*21*).

There were two false-negative radionuclide venograms. In both cases contrast venography showed small thrombi attached to the wall of the vein. Retrospectively, a small area of decreased radioactivity was detected in the region corresponding to the thrombus, but neither radioactivity collection nor

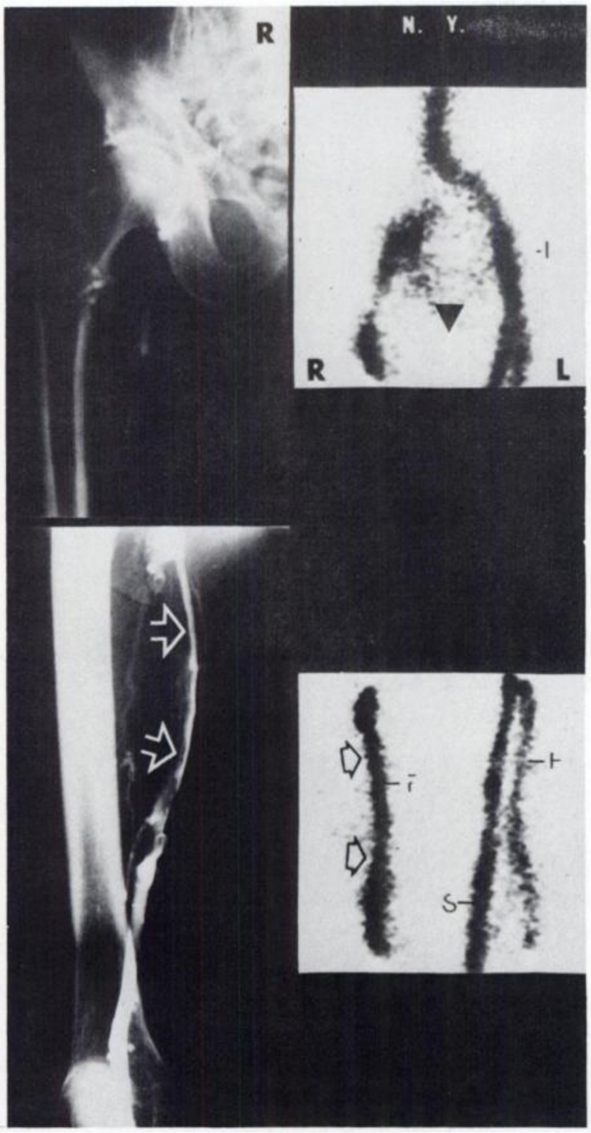

FIG. 5. Radionuclide venogram of pelvic region shows areas of decreased radioactivity and collateral flow corresponding to extensive thrombosis in iliac vein, confirmed on contrast venogram. Area of narrowed radioactivity flow is noted in right femoral vein on radionuclide venogram, while contrast venogram shows large thrombus in same location (arrows). Venograms from left pelvis and thigh are normal. (Landmarks are same as in Fig. 1.)

collateral flow was apparent on the radionuclide venogram.

In the 16 true-positive radionuclide venograms from 16 patients, abnormal findings were due to extrinsic compression of the vein or, in two patients, invasion of the vein by metastatic carcinoma. Complete four or six views of perfusion lung scintigraphy and ventilation scintigraphy were performed in 12 patients with deep-vein thrombosis shown by both radionuclide and contrast venography. Perfusion defects consistent with pulmonary embolism were found in seven (58%). One of two patients with false-negative radionuclide venograms and one of three patients with false-positive radionuclide venograms also had pulmonary embolism shown on perfusion lung scintigraphy. Perfusion lung scintigraphy was not done in patients with negative venograms.

DISCUSSION

The need for a simple and reliable technique to detect venous thrombosis has led to the development of many different procedures. Among these, radionuclide venography appears to be the most simple and routinely available test, since it can be performed during perfusion lung scintigraphy.

Results from this study indicate that radionuclide venography is a highly sensitive and reliable technique for detecting venous thrombosis when the scintigram is properly analyzed. The abnormal findings consistent with venous thrombosis are as follows:

1. Area of decreased radioactivity flow corresponding to the region of thrombosis.
2. Abnormal collateral flows.
3. Stasis of radioactivity below the region of thrombosis.

Stasis of radioactivity alone in the calf region does not indicate thrombosis in the calf veins. When the finding of simple stasis in the calf region was regarded as nonspecific, overall findings from the radionuclide venography agreed with contrast venography findings in 89%. This result is superior to the average results from labeled fibrinogen tests and is in

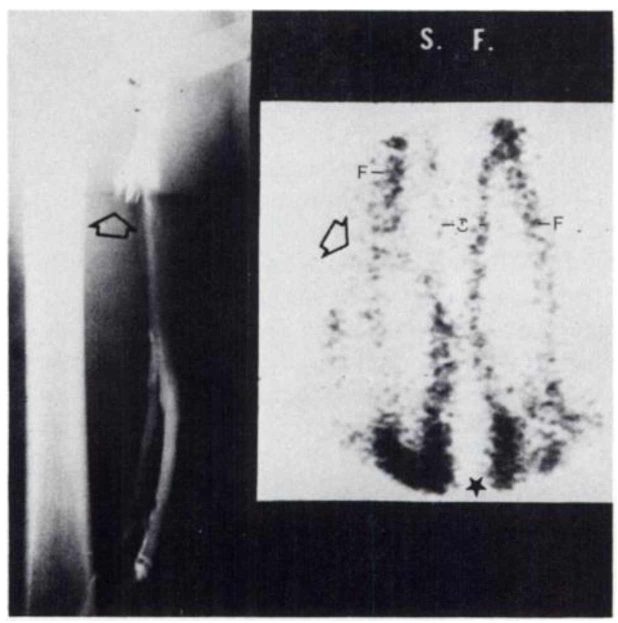

FIG. 6. Radionuclide venogram from both thighs shows normal left femoral and saphenous veins. Collateral flows are noted in right femoral region (arrow). This radionuclide venogram was interpreted as abnormal. Contrast venogram revealed variation of right femoral vein, i.e., triple femoral vein (arrow). (Landmarks are same as in Fig. 1.)

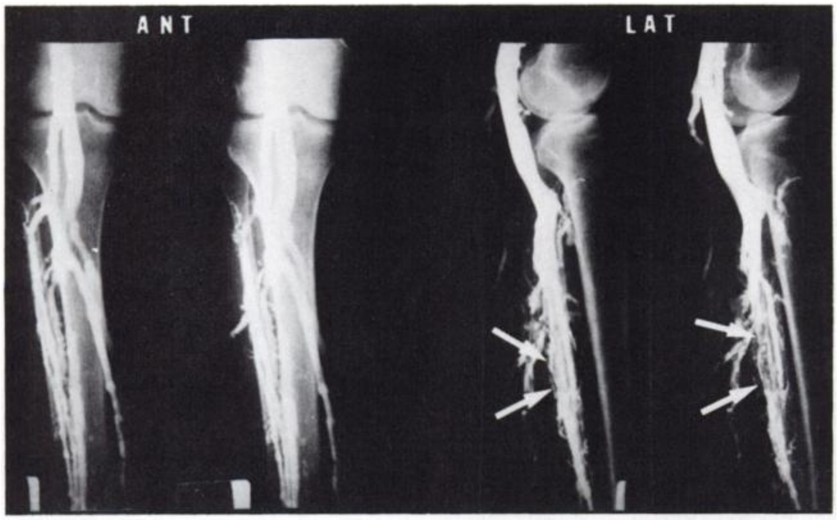

FIG. 7. Contrast venograms from lower leg of patient with progressive signs and symptoms of right calf-vein thrombophlebitis. Anterior views failed to show thrombosis, whereas large area of thrombosis in posterior tibial vein was clearly imaged in lateral views (arrows).

close agreement with recent RNV studies done at other institutions (*17,18*).

Simplicity of the technique and accuracy approaching 90% make the RNV the best routine procedure for detecting thromboembolic venous disease. Simultaneous imaging of the lung and visualization of the pelvic region and the lower extremity, without additional injection, are particularly advantageous with this technique.

Although contrast venography is the most valuable method for detecting venous thrombosis, difficulties in the technique and complications make the procedure unsuitable for routine use. Additional studies are often necessary to image the iliac and upper femoral veins (*1,2*). Moreover, small clot formation may escape detection even with contrast venography (*1,22,23*). We had a patient with progressive signs and symptoms of calf-vein thrombophlebitis in whom initial anterior views on the contrast venogram failed to indicate thrombosis. A repeat contrast venogram with lateral views showed a large thrombus in the posterior tibial vein (Fig. 6).

Many investigators (*1,11,23*) have found clinical signs and symptoms to be unreliable for the diagnosis of venous thrombosis. The rate of false-positive clinical findings was also high in our study. Results from both venographies were normal in 15 out of 31 patients (48%) with clinical signs and symptoms.

ACKNOWLEDGMENT

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FOOTNOTES

* Either the Searle Radiographics LFOV or its Pho/Gamma IV scintillation camera (Des Plaines, Ill.).

† Renografin-60, E. R. Squibb & Sons (Princeton, N.J.).

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