Dynamic Radionuclide Venogram Correlation with Radiographic Contrast Venography

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A simple technique of dynamic radionuclide venography— using a Searle LFOV gamma camera and an associated whole-body scanning couch—was investigated to demonstrate venous flow from the foot to the inferior vena cava on a single image. Results of this method were correlated with radiographic contrast venography in prospective studies in 84 patients. Correlation between radionuclide and contrast venograms was 79% in the pilot study; it improved to 96% with modification of scan technique and assessment criteria in a second study. Hot spots and stasis proved to be unreliable indicators of deep vein thrombosis (DVT). The radionuclide venogram appearance that correlated best with contrast studies was diversion of the flow from deep to superficial veins.

Radionuclide venography was introduced in 1969 for the diagnosis of deep vein thrombosis (*1*). Initial enthusiasm (*2–8*) subsided following reports of unreliability of the static imaging techniques employed, but the introduction of a large field gamma camera and a synchronized scanning couch (Searle, Des Plaines, IL) allowed dynamic imaging of axial venous flow on a single image (*9–10*). Our report of a prospective study in 84 patients compares dynamic radionuclide venography to standard radiological contrast venography in the demonstration of DVT.

Materials and Methods

Informed consent for the venography procedures was obtained for 84 patients referred for lung scans. The standard lung imaging dose of 2 mCi of Tc-99m macroaggregated ferrous hydroxide (MAFH) was divided equally and administered simultaneously through the dorsal pedal veins of each foot for the radionuclide venogram.

Twenty-one gauge scalp vein needles were used to allow subsequent contrast injection for correlative radiographic contrast venography. Cobalt-57 marker sources were taped to the skin on the lateral and medial borders of the legs at the level of ankles, knees, and upper thighs. These reference markers allowed superficial vein activity to be distinguished from that in deep veins. Ankle tourniquets were used to direct flow through the deep veins during injection of Tc-99m MAFH into the superficial pedal veins in each foot. To ensure simultaneity, injection of Tc-99m MAFH in both feet was performed by one operator—who then administered a 10-ml saline flush through a three-way stopcock.

The instrument procedure for dynamic radionuclide venography was as follows:

Fig. 1.1: The couch bearing the supine patient was positioned so ankles and calves were beneath the gamma camera head.

Fig. 1.2: The scanning couch required specific activation by first moving the couch in a cephalad direction thus bringing the feet under the camera head.

Fig. 1.3: At the limit of couch movement automatic reversal brought the ankles and calves back to the original position under the camera head; then the pause facility was activated.

Fig. 1.4: The couch was then moved by manual control to facilitate insertion of scalp vein needles into the feet. Cobalt-57 marker sources were taped in position and the couch returned to the point at which the pause facility was activated.
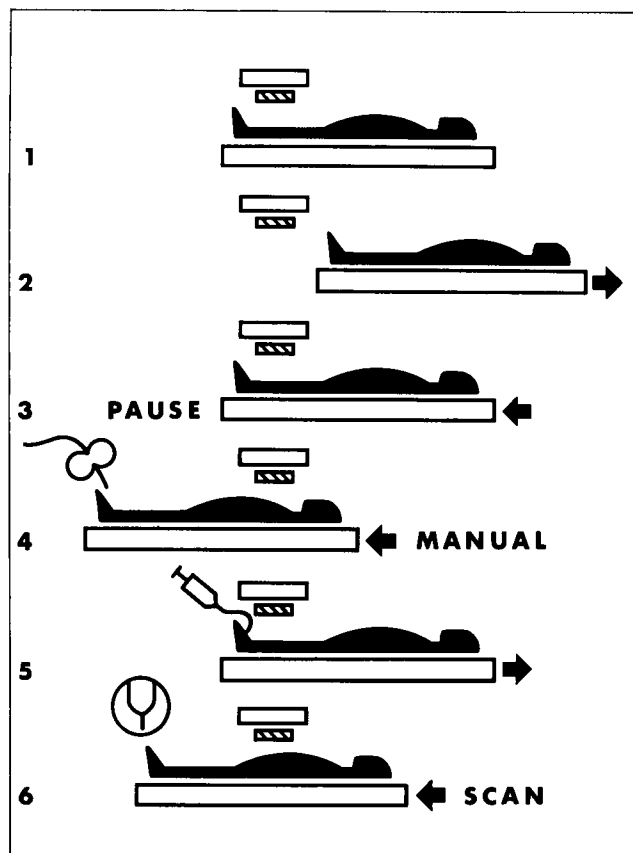

FIG. 1. Searle scanning procedure: Arrows show direction of couch movement for each phase of scanning.

Fig. 1.5: Tc-99m MAFH was simultaneously administered into each foot by one operator and scanning was commenced during the saline flush. Tourniquets were released at this point in the pilot study.

Fig. 1.6: Couch speed was varied according to the rate of venous ascent as monitored on the persistence oscilloscope.

The scan terminated automatically at the 100-cm mark but could be stopped by manual control at any time. A display field length of 100 cm was selected to produce maximum image size using a scan width of 30 cm and length 0-100 cm. Other control console parameters were set as for routine whole-body scanning to produce a one view, dual-intensity exposure format on the micro-dot imager (Searle, Des Plaines, IL). The selected output intensity of this device was 40 low and the photometer was balanced. The film cassette remained closed until immediately prior to injection of Tc-99 MAFH.

Following completion of the radionuclide venogram, heparinized saline was introduced into the needles taped to the feet. We did this to maintain patency during subsequent routine eight-view perfusion lung imaging study and transport to the Department of Radiology for the correlative radiologic contrast venogram.

The contrast venograms were interpreted according to standard radiologic criteria. The radionuclide venograms were independently assessed according to major and minor criteria. Major criteria used were superficial flow alone, or in conjunction with diversion of flow from deep veins; and block with or without collateral flow. Less reliance was placed on the minor criteria of stasis, hot spots, and asymmetry.

Criteria for radionuclide venogram interpretation were reassessed after the pilot study in an attempt to improve diagnostic accuracy. As a result, only diversion of flow from deep to superficial veins or asymmetry of axial flow was considered indicative of DVT.

The scanning technique was modified so that legs, pelvis, and abdomen were scanned twice. For the first passsage, tourniquets remained tight to occlude superficial veins and demonstrate the deep venous system alone. The scanning couch was repositioned and the second scan commenced on release of the tourniquets as soon as possible after completion of the first pass.

The amended criteria and modified technique were applied in a prospective study of 25 patients with previously abnormal perfusion lung scans or clinical suspicion of DVT referred to the Department of Nuclear Medicine.

Results

• **Pilot Study:** The correlation of radionuclide venography in the pilot study of 112 limbs in 59 patients was 79% using contrast venography as the reference standard. There were ten false positive and thirteen false negative radionuclide venograms.

• **Modified Study:** The correlation of radionuclide venography and contrast venography for 49 limbs in 25 patients was 96%. Only one false negative intrepretation was made.

The improved definition of axial venous flow following modification of the radionuclide venography
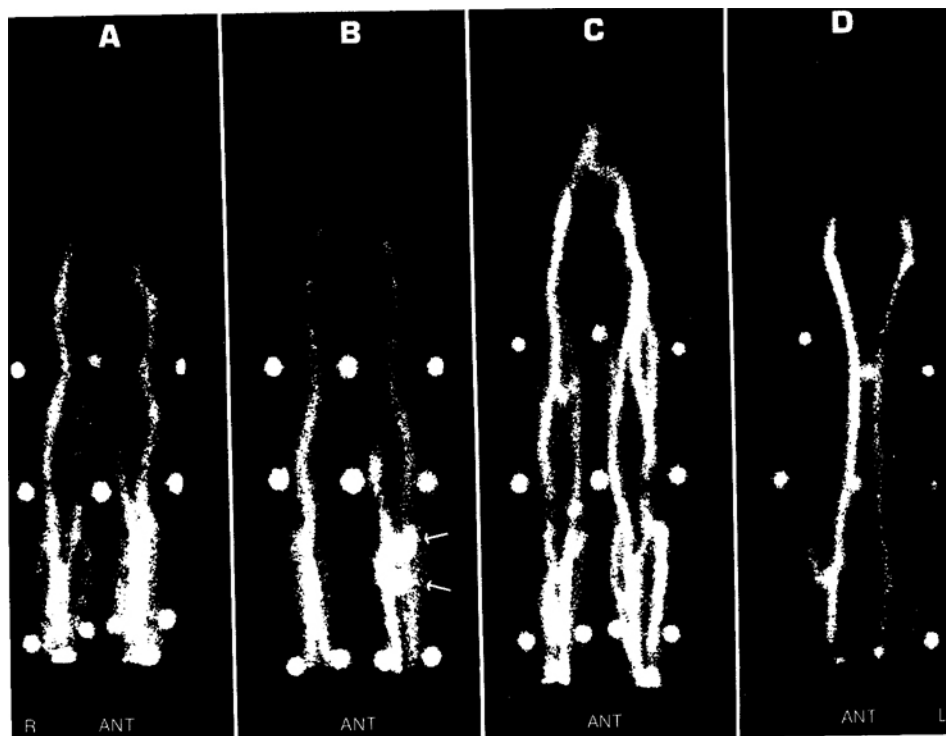

FIG. 2. Radionuclide venograms from the pilot study show stasis in the calf (A), hot spots (B); and hot spots, flow diversion, and superficial filling (C) in the presence of normal radiographic contrast venography. Deep vein thrombosis was confirmed where flow was exclusively through superficial veins (D).
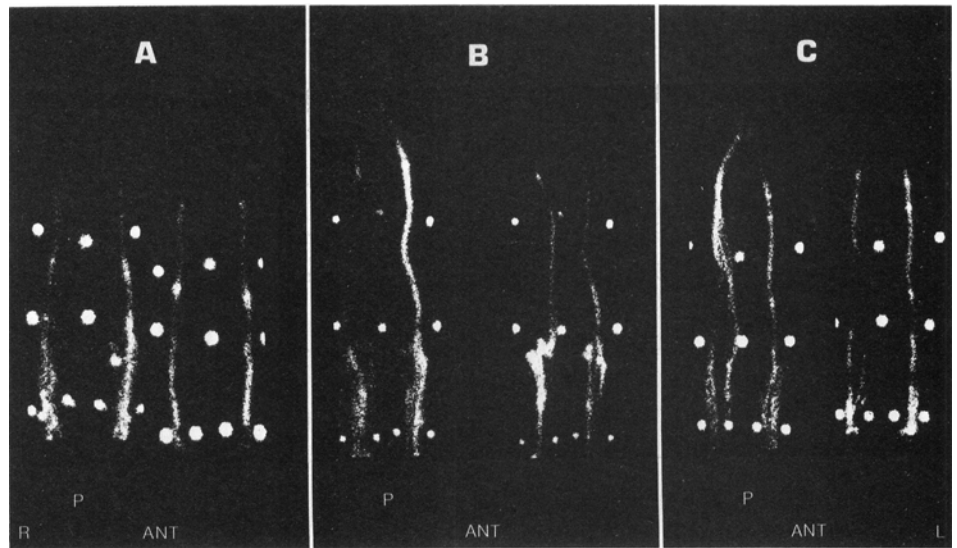
FIG. 3. Postrelease (P) radionuclide venograms in the modified study show normal flow (A) with normal contrast venogram. Flow diversion in calf (B) and asymmetric flow (C) were seen in patients with corresponding abnormalities on contrast venography.

technique is evident from comparison of the examples illustrated in Figures 2 and 3.

Discussion

All results of dynamic radionuclide venography in this study were assessed by comparison with radiologic contrast venography, which is the most reliable test available for the demonstration of DVT *(11)*. Disadvantages of the radiologic technique include morbidity associated with pressure injections and consequences of allergic reactions to iodine—not diagnostic insensitivity, although adequate demonstration of pelvic veins is sometimes difficult.

There are no generally accepted strict criteria for diagnosis of DVT by radionuclide venography. The appearance that correlated best with thrombi demonstrated by radiographic contrast venograms in our study was diversion of flow from deep to superficial veins. We found that hot spots and stasis were not reliable indicators of DVT.

Dynamic radionuclide venography has proved diagnostically comparable to radiographic contrast venography without the associated morbidity. This technique may be applied when administration of contrast media is contraindicated as in multiple myeloma (Fig. 4) or known allergy to iodine.

Standard radionuclide venograms *(3-6,8)*, which record a sequence of static images using serial release of multiple tourniquets, are often difficult to interpret especially in assessment of the significance of hot spots. Dynamic radionuclide venography has the advantage of directly imaging axial venous blood flow without requiring artificial obstruction by tourniquets at calf or knee level.

A single dynamic radionuclide venogram image demonstrates venous flow from foot to inferior vena cava and eliminates problems arising from superimposition of static radionuclide images. The administered radioactivity of 1 mCi per limb is less than half that of static techniques *(3,4,6-8)*.
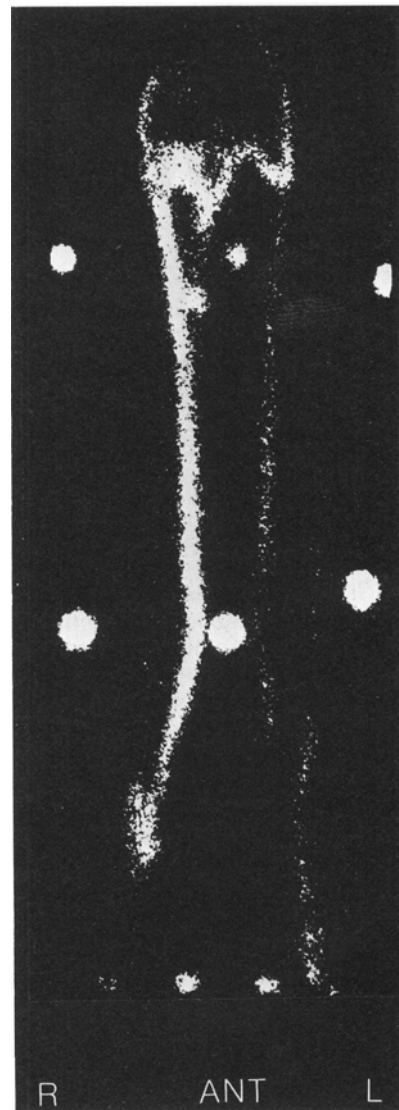

FIG. 4. Radionuclide venogram shows block in the right calf with superficial diversion and pelvic collateral flow in a patient with multiple myeloma in whom radiologic contrast studies were precluded.

Lung imaging after dynamic radionuclide venography demonstrated segmental hypoperfusion consistent with pulmonary embolism in 41 of the 84 patients. Pulmonary embolism was diagnosed in 19 of 28 patients with positive dynamic radionuclide venograms in the pilot study and 6 of 9 patients in the modified series. Negative dynamic radionuclide venograms were associated with positive lung scans in 10 of 31 patients in the first series and 6 of 16 patients in the second study.

The dynamic radionuclide venogram does not increase radiation exposure and adds less than 15 min to the standard lung imaging procedure. No side effects were encountered in our study; the dynamic radionuclide venogram contributed to the diagnostic information available for interpretation of lung perfusion abnormalities.

References

1. Webber MM, Bennett LR, Cragin M, et al: Thrombophlebitis — demonstration by scintiscanning. *Radiology* 92: 620–623, 1969

2. Duffy GJ, D'Auria D, Brien TG, et al: New radioisotope test for detection of deep venous thrombosis in the legs. *Br Med J* (1) 712–714, 1973

3. Rosenthall L, Greyson ND: Observations on the use of ^{99m}Tc albumin macroaggregates for detection of thrombophlebitis. *Radiology* 94: 413–416, 1970

4. Henkin RE, Yao JST, Quinn JL, et al: Radionuclide venography (RNV) in lower extremity venous disease. *J Nucl Med* 15: 171–175, 1974

5. Pollak EW, Webber MM, Victery W, er al: Radioisotope detection of venous thrombosis — venous scan vs fibrinogen uptake test. *Arch Surg* 110: 613–616, 1975

6. Ryo UY, Qazi M, Srikantaswamy S, et al: Radionuclide venography: Correlation with contrast venography. *J Nucl Med* 18: 11–17, 1977

7. Vlahos L, MacDonald AF, Causer DA; Combination of isotope venography and lung scanning. *Br J Radiol* 49: (586) 840–851, 1976

8. Hayt DB, Blatt CJ, Freeman LM: Radionuclide venography: Its place as a modality for the investigation of thromboembolism phenomena. *Semin Nucl Med* 7: 263–281, 1977

9. Van Kirk OC, Burry MT, Jansen AA, et al: A simplified approach to radionuclide venography: Concise communication. *J Nucl Med* 17: 969–971, 1976

10. Gaston EL, Gaspard CL, Brooks AC: Dynamic leg scintigraphy with an LFOV scintillation camera. *J Nucl Med Tech* 6: 27–29, 1978

11. Fishbein E: Deep-venous thrombosis detection. *Appl Radiol* 6: 96–98, 1977