[^{99m}Tc] Pertechnetate Radionuclide Venography—Large-Volume Injection Without Tourniquet

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Radionuclide venography was performed in patients who were suspected clinically to have thromboembolic disease of the lower extremities and/or pelvis. A moderately large volume of pertechnetate was administered in the dorsal vein of each foot without the benefit of applied tourniquets at the time of injection. Sixty-five (27.2%) of 242 studies were abnormal; the majority revealed defect(s) and collaterals, some collaterals only, and a few defects only. In 140 normal patients only the deep venous system was outlined in 74.5%, while the remainder defined one or both sides of the superficial venous system (great saphenous vein). The merits and apparent advantages derived from radionuclide venographic procedure are discussed. The method is simple, reproducible, and useful in assessing thromboembolic disease, particularly in the deep venous system of the lower extremities and pelvis.

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The clinical value derived from the performance of radionuclide venography in the assessment of thromboembolic disease of the lower extremities and pelvis is widely recognized and accepted (*1–5*). This acceptance is due not only to the inherent benignity of the procedure but also because it possesses high accuracy and reliability (*6–8*).

Depending on the type of tracer preparation used, radionuclide venography is said to be circulatory, biochemical, or immunologic in nature (*9*). In previously published reports, dynamic radionuclide venography required the application of either single or double tourniquets at the time of tracer injection (*5,7,10,11*). This communication presents and discusses our experience in a series of patients who underwent a modified type of radionuclide venography using a moderately large volume of technetium-99m as pertechnetate. In contrast with previously accepted approaches, tourniquets were released at the time of i.v. tracer injection.

METHODS

From July 1974 to June 1977, 228 adults, aged 21–77 yr, were suspected clinically to have phlebothromboembolic disease of the lower extremities and/or pelvis, and a total of 242 radionuclide venograms were done. Eight patients underwent two studies each, while three others had a series of three each. Of the 242 studies performed, 197 were simultaneously performed in both lower limbs, but in 34 only one of the limbs could be successfully injected.

Two separate doses of 6–8 mCi of [^{99m}Tc] pertechnetate are diluted into two separate volumes of 6–10 cc of normal saline solution. One dose is injected slowly into the dorsal vein of one foot, while simultaneously the other foot receives the other dose, both tourniquets being completely released at the time of the procedure. Scalp-vein needles (gauge 23 or 25) are used. A gamma camera with an all-purpose, low-energy collimator views an area from 5 in. below the knees to about 2 in. or so below the xiphoid process—a region that extends roughly from the origin of the popliteal vein, or lower, up over most of the inferior vena cava. In the earlier cases that were studied, a marker was placed lateral to one knee.

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TABLE 1. PERTECHNETATE RADIONUCLIDE VENOGRAPHY (242 CASES)

(a) Normal	166	(68.5%)
Both limbs	140	
One limb	26	
(b) Abnormal	65	(27.2%)
Both limbs	57	
One limb	8	
(c) Equivocal	11	(4.4%)

TABLE 2. RADIONUCLIDE VENOGRAPHY—ABNORMALITIES IN 65 CASES

(a) Defect(s) and collaterals	45
(b) Collateral(s), but no definite defects observed	10
(c) Defect(s) w/o collaterals	7
(d) Inferior vena caval abnormality	3

The movement of the injected radioactivity is monitored by oscilloscope, while data are stored on magnetic tape and concurrently recorded by hand-pulled Polaroid films or on 3-sec transparency film frames using a multi-imager system. The patient lies supine on the imaging table, and the initial area covered by the camera is proximal to the sites of injection. The patient and table are moved toward the feet in one or two maneuvers, depending on the subject's habitus, as the flow of the injected radionuclide progresses.

RESULTS

Table 1 summarizes the radionuclide venographic studies. Of 242 venograms, 65 (27.2%) were abnormal, 11 (4.4%) equivocal, and 166 (68.5%) normal. The 65 abnormal studies presented a diversity of patterns (Table 2).

In those patients who had only one limb successfully imaged, no assessment is reached as to the status of its opposite counterpart. Some conclusion, however, is drawn from the venogram of the limb studied, particularly when an abnormal pattern was observed.

In 74.5% of the normal studies, where bilateral injections were administered, the deep venous system is outlined, including the inferior vena cava, the common iliac, femoral, and popliteal veins, and at times the anterior or posterior tibial veins. This normal configuration resembles a wishbone, or an inverted Y with long arms (Fig. 1A). Normally the deep femoral vein is not outlined. Normal iliac veins may show relatively less intense activity. We have attributed this to the dipping of the iliacs into the pelvis as they leave the iliofemoral junctions and pass farther from the camera. The effect is most

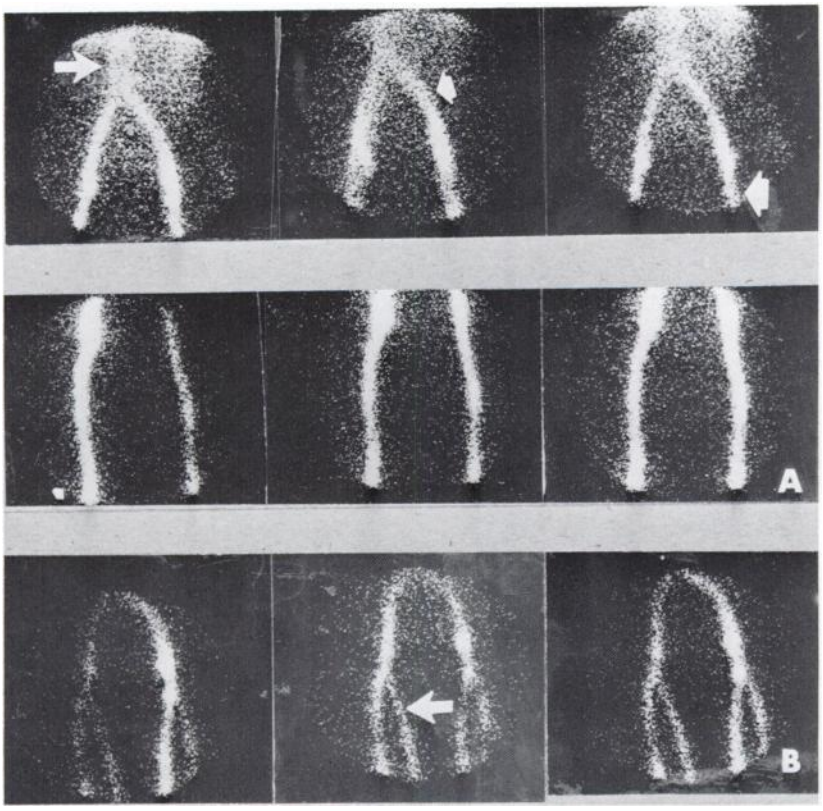


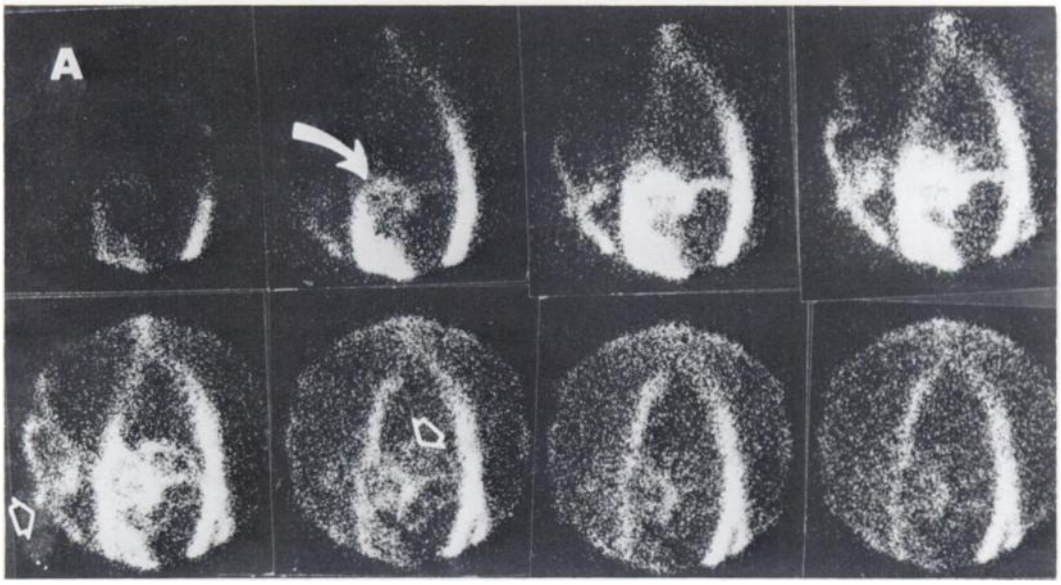
FIG. 1. (A) Normal deep venous system: inferior vena cava (1st arrow), common iliac (2nd arrow), femoral (3rd arrow), popliteal and anterior or posterior tibial veins. (B) Normal: deep and superficial (great saphenous) veins (arrow).

noticeable in individuals with large abdominal girth. In 25.5% of the studies, the great saphenous vein was also outlined, either on one side only or bilaterally (Fig. 1B).

DISCUSSION

In our series of studies, the clear delineation of the deep venous system, whether normal or abnormal, prompts us to question the need of applied tourniquets at the time of radionuclide injection. Understandably, in contrast phlebography the use of tourniquets may be mandatory, because the amount of contrast material that normally gets into the deep system is insufficient to outline the veins adequately (*12*). In radionuclide venography by our method, this does not appear to be so. Moreover, the problems of layering and streamlining encountered in contrast phlebography are probably minimized or obviated by the use of tourniquets. In some instances, comparative post-tourniquet contrast studies are usually included as part of a regular phlebography study to outline the soleus and gastrocnemius veins and also others more superficial (*12*).

Various radiotracers are in current use for the detection of phlebothromboembolic disease of the lower extremities and pelvis. These include fibrinogen tagged with I-123 or I-125 (*3,4,13*), radiolabeled streptokinase and urokinase (*14*), Tc-99m-tagged



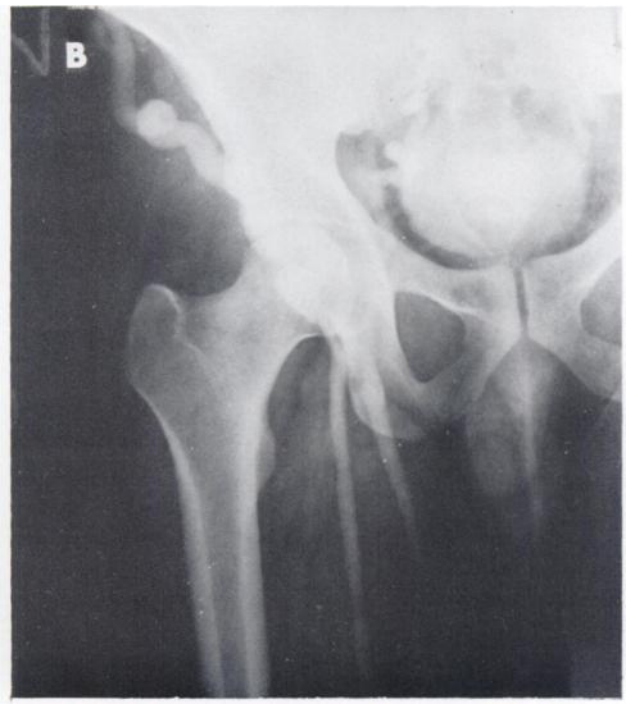


FIG. 2. (A) Occlusion at the right iliofemoral junction (arrow); ipsilateral iliac vein not outlined; whorled collaterals lateral and medial to site of obstruction. (B) Corresponding venogram. Note lack of luxuriant collaterals seen on radionuclide study.

FIG. 3. Recanalization demonstrated by serial studies in young woman with thromboembolic disease.

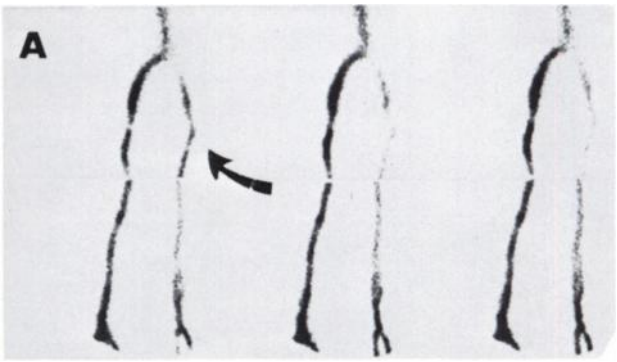
albumin microspheres (*5*), or macroaggregated albumin (*7*), etc. The volumes and doses used with preparations are invariably limited by the nature of the individual tracer.

Doses of pertechnetate larger than those we customarily use could be administered to each limb without risk. The purpose of dilution is to obtain a volume that is manageable during the time of injection, and also to fill more adequately the venous system(s) to be outlined. The release of tourniquets before the actual injection minimizes gradients newly created by the tourniquet. These measures, in addition to the simultaneous, slow, and practically pressureless injection, allow the tracer to blend into the prevailing flow pattern in the venous system and hence to outline the pre-existing route(s) in that particular limb and the pelvis. Hence this mode of administration is probably more physiologic.

Gradients existing within the veins determine the flow pattern of blood within that system, whether normal or abnormal. Alternate routes or collaterals develop in abnormal states if the path has been impeded—e.g., by thromboembolic disease or less commonly by occlusion or pressure from without, as in pelvic malignancies. In chronic obstruction, the collaterals predominate and may eventually assume the main route of circulation.

In the majority of our abnormal studies, the combined features of defect(s)—due presumably to clot(s) and associated ipsilateral collaterals—are characteristic findings for phlebothromboembolic disease (Fig. 2 A and B). Extensive occlusion may result in absence of activity throughout the entire length of a vein. Recanalization in such instances can be documented by serial gamma venography (Fig. 3).

When iliofemoral venous occlusion occurs, crossover veins or collaterals invariably appear at the lower mid pelvis, bridging the two iliacs. They occur either as a single vein, straight or tortuous, with or without a profusion of whorled collaterals. Frequently the configuration resembles the letter A, sometimes with interrupted upper side. The features of the collaterals seen are influenced by the portion of the vein obstructed and probably by the size and age of the clot. In our experience, the collaterals as observed on contrast venography are not as luxuri-



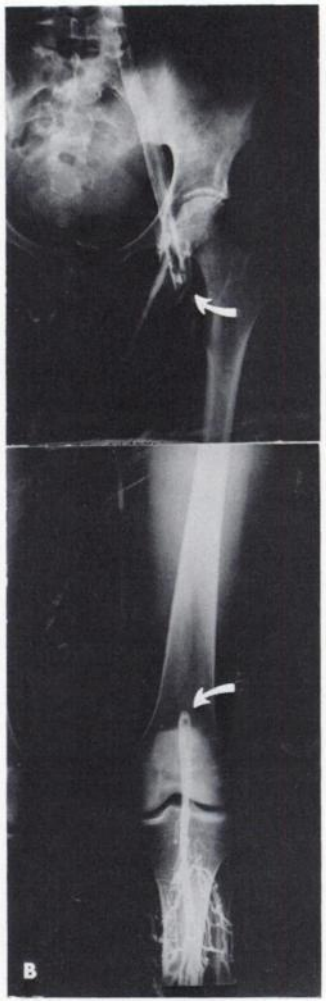


FIG. 4. (A) Angle of entry of great saphenous vein is accentuated in occlusion of entire ipsilateral femoral vein (arrow). (B) Contrast venography. Note sharply truncated popliteal and proximal femoral veins (arrows).

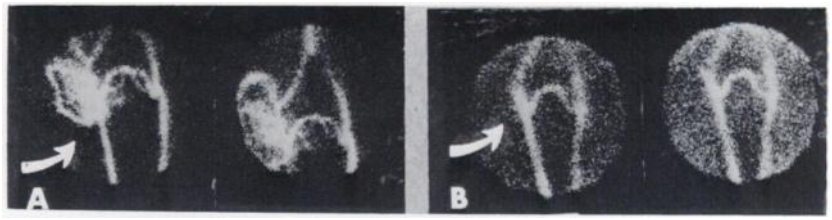


FIG. 5. (A) Luxuriant whorled collaterals at iliofemoral junction (arrow), but no demonstrable defect. (10–20–76) (B) Same patient, now on anticoagulant therapy: bridging vein persists, but whorled collaterals have disappeared. (11–30–76)

antly demonstrated as they are by radionuclide venography.

Unlike the femoral vein, which "blends" smoothly into the iliac, the great saphenous vein enters the groin and joins the femoral at a more prominent angle. This angle of entry is accentuated if the entire ipsilateral femoral vein is occluded. When observed, this angle offers an important warning that such occlusion may be present (Fig. 4 A and B).

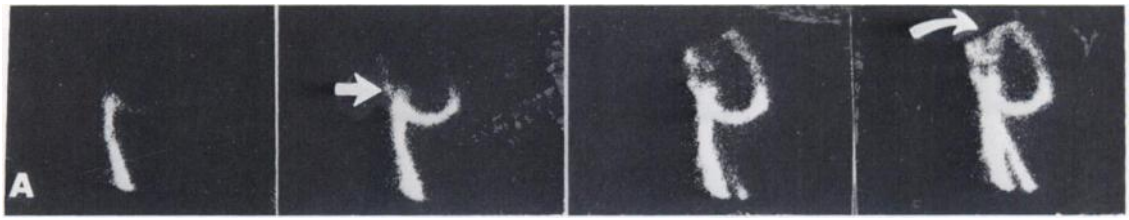
In ten studies, collaterals were seen but no accompanying defects could be identified. The defects may well have been masked by the presence of luxuriant adjacent collaterals. In one patient studied, the lateral whorled collaterals disappeared promptly following adequate anticoagulation therapy (Fig. 5 A and B).

In scintigrams considered equivocal, the findings consisted of short collaterals below the knees, usually between distal portions of the saphenous veins and other leg veins. These collaterals might represent varicose veins, but this has not been established.

Because of our policy to keep the procedure a noninvasive one, cut-downs have not been resorted to, even when avenues of injection are inaccessible. However, if one limb has an accessible vein, the procedure is completed on that side.

In 34 such unilateral limb studies, there were eight abnormal ones. In one patient, the entire length of the femoral vein was occluded on the side studied. Nevertheless, the deep femoral and great saphenous veins were outlined, as well as a crossover vein to the opposite side. After the radionuclide traversed the bridging vein, it ascended the contralateral iliac and then outlined the inferior vena cava. An interesting finding was the presence of retrograde activity filling the ipsilateral iliac vein above the site of venous thrombosis (Fig. 6 A and B). This abnormal pattern undoubtedly followed the direction of flow prevailing in the deep venous system at the time of study.

This mode of radionuclide venography is simple, reproducible, and valuable in helping to assess thromboembolic disease of the lower extremities and



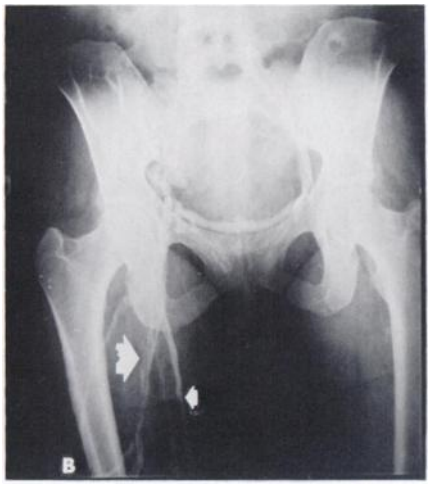


FIG. 6. (A) Only the symptomatic limb was successfully studied. Right femoral is occluded at iliofemoral junction seen (straight arrow). Activity crosses over to the contralateral iliac, ascends to inferior vena and retrograde flow is appreciable (curved arrow). (B) Contrast venography parallels the pattern demonstrated on radionuclide study. Femoral vein not outlined, instead deep femoral (large arrow) and great saphenous vein (small arrow) are seen.

pelvis. Moreover, no complications from this approach have been encountered in any of our patients.

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REFERENCES

1. PALKO PD, NANSON EM, FEDORUK SO: The early detection of deep vein thrombosis using I^{131}-tagged human fibrinogen. *Can J Surg* 7: 215–226, 1964

2. ATKINS P, HAWKINS LA: Detection of venous thrombosis in the legs. *Lancet* 2: 1217–1219, 1965

3. KAKKAR VV, NICHOLAIDES AN, RENNEY JTG, et al: ^{125}I-labelled fibrinogen test adapted for routine screening for deep vein thrombosis. *Lancet* 1: 540, 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. WEBBER MM, POLLAK EW, VICTERY W, et al: Thrombosis detection by radionuclide particle (MAA) entrapment: correlation with fibrinogen uptake and venography. *Radiology* 111: 645–650, 1974

6. CARETTA RF, DENARDO SJ, DENARDO GL, et al: Early diagnosis of venous thrombosis using ^{125}I-fibrinogen. *J Nucl Med* 18: 5–10, 1977

7. RYO UY, QAZI M, SRIKANTASWAMY S, et al: Radionuclide venography: correlation with contract venography. *J Nucl Med* 18: 11–17, 1977

8. WEBBER MM: Labelled albumin aggregates for detection of clots. *Semin Nucl Med* 7: 253–261, 1977

9. TOW DE: Thrombus detection: Here and now. *J Nucl Med* 18: 90–92, 1977

10. ROSENTHALL L: Radionuclide venography using Technetium 99m pertechnetate and the gamma scintillation camera. *Am J Roentgenol Radium Ther Nucl Med* 97: 874–879, 1966

11. HAYT DB, BLATT CJ, FREEMAN LM: Radionuclide venography: Its place as a modality for the investigation of thromboembolic phenomena. *Semin Nucl Med* 7: 263–281, 1977

12. GROLLMAN JH, WEBBER MM, GOMES AS: Phlebography and radionuclide clot localization in the lower extremities. *Radiol Clinics of North America* 14: 371–385, 1976

13. DENARDO SJ, DENARDO GL: Iodine-123-fibrinogen scintigraphy. *Semin Nucl Med* 7: 245–251, 1977

14. CHARKES ND, MALMUD LS, STERN H: Comparative evaluation of current scanning agents for thrombus detection. In *Radiopharmaceuticals*, Subramanian G, Rhodes BA, Cooper JF, and Sodd V, eds. Society of Nuclear Medicine, New York, 1975, pp 525–534