jnm/ CONCISE COMMUNICATION

RADIONUCLIDE VENOGRAPHY

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A technique for radionuclide venography of the legs and pelvis using $^{99m}TcO_4^-$ is described. Results in 37 patients without and in 40 patients with occlusive venous disease are presented. The method is simple, well tolerated, and correlates well with Doppler flow studies of the venous system.

Thrombotic disease involving the deep venous system of the legs and pelvis remains an important clinical problem. Clinical assessment is often difficult due to the inacurracy of physical diagnosis. Ascending contrast venography (*1*), radioactive iodine labeled fibrinogen (*2,3*), and ultrasonic Doppler flow studies (*4*) have all been applied with some degree of success to the diagnosis of this disease. However, all have some disadvantages. Ascending contrast venography is difficult to perform and often unpleasant for the patient. Labeled fibrinogen and Doppler studies are not suitable for studying the iliac veins and inferior vena cava, and neither produces a readily assimilated visual image. We have developed a rapid, simple technique for visualizing the deep venous system from the knee level to the distal inferior vena cava following the injection of $^{99m}TcO_4^-$ into the dorsal vein of both feet. The details of this new technique and the results in 77 patients are presented.

MATERIALS AND METHODS

The 77 patients studied consisted of 37 patients, selected from patient groups undergoing routine brain scanning without historical or physical evidence of deep venous disease and 40 patients with known venous disease referred from the Peripheral Vascular Laboratory or the clinical wards. All patients evaluated with radionuclide venography were also studied with Doppler ultrasonic flow studies of the deep venous system of the lower extremities and common femoral veins.

Radionuclide venography was performed in the following fashion. The dorsal vein of both feet, under local anesthesia, was cannulated with a 21-gage, thin-wall scalp-vein needle. The knees, upper medial aspect of both thighs, and the pubic symphysis were marked with markers containing 50–100 μC of $^{99m}TcO_4^-$. Single tourniquets were applied just above the malleoli and 7.5 mCi $^{99m}TcO_4^-$ in 30 cc of normal saline was injected slowly into each foot over a 10–30-sec period. The occlusive tourniquets force the injected pertechnetate into the deep venous system. Imaging was performed using a Nuclear-Chicago Pho/Gamma III or HP camera with a high-energy diverging collimator. Images were recorded by serial scintiphotos at 5-sec intervals and the data were stored on videotape for later reproduction and display.

Initially, the camera was centered over the thighs. Following adequate visualization of both superficial femoral veins, the camera was positioned over the pelvis and the common femoral veins, iliac veins, and the vena cava were imaged.

After adequate imaging of the pelvic venous system, the detector was centered over the inguinal region, the occlusive tourniquets were released, and the long saphenous at its confluence with the common femoral vein was imaged. This allowed clear delineation of the saphenous system from the deep venous system.

Doppler venous studies were performed by directing a 5–10-MHz sound beam generated by a piezoelectric crystal through the skin to the underlying vein. When the ultrasound encounters moving particles in the blood, its frequency is shifted by an amount proportionate to the flow velocity. The shifted, backscattered frequencies and the nonshifted

Received Nov. 2, 1972; original accepted Dec. 7, 1972.

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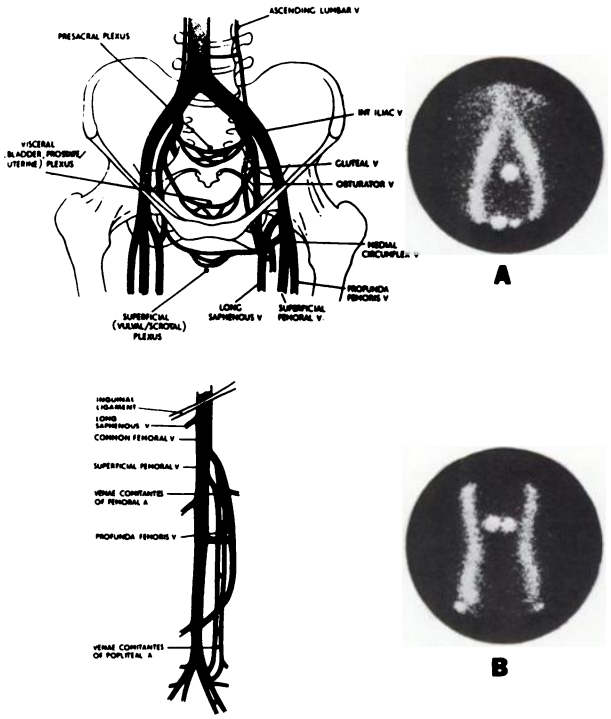

FIG. 1. Radionuclide venogram in patient without venous disease. (A) Image of pelvic venous system from upper thigh (lower markers) to distal inferior vena cava. Upper marker is over pubic symphysis. (B) Image of deep venous system of thigh from knee to inguinal ligament. Upper markers correspond to lower markers in A. Single tubular structures represent superficial femoral veins. Normal anatomy of region imaged illustrated on left.

signal from stationary tissue interfaces are detected by a receiving crystal, mixed, and amplified. Analysis of these signals obtained at rest and with various augmentation maneuvers is performed. Characteristic signal patterns have been documented for the posterior tibial vein, superficial femoral vein, and common femoral vein (*4*).

RESULTS

In all patients in whom it was possible to cannulate the dorsal vein of the foot, satisfactory images of the deep venous system were obtained. In patients without historical, physical, or Doppler evidence of venous disease, a typical pattern was seen as shown in Fig. 1. The initial images showed a single tubular channel representing the superficial femoral vein (Fig. 1B). Pelvic imaging showed a typical wishbone configuration representing, in order, the common femoral vein, external iliac vein, common iliac vein, and distal inferior vena cava (Fig. 1A). In this wishbone pattern, the common iliac vein was visualized as an area of decreased activity with retention of the tubular-image profile. The decrease in activity at this point is due to both tissue attenuation of photon energy as the common iliac vein descends into the pelvis and dilution of the radioactive bolus by entrance of the internal iliac (hypogastric) vein. The patient was then repositioned with the inguinal area centered under the camera; the tourniquets were released, and the long saphenous vein at its confluence with the common femoral vein was imaged. The long saphenous vein was seen to lie medial to the superficial femoral vein in close proximity to the marker on the medial thigh.

In 40 patients with occlusive venous disease, the pattern clearly deviated from the normal configuration described above. Abnormal patterns consisted of an occlusion in a specific venous channel accompanied by visualization of collateral pathways. Representative cases illustrating abnormal patterns with collateral flow are illustrated in Figs. 2 and 3. The pattern of collateral flow visualized in the pelvic venous system was useful in localizing the level of the occlusion. As can be seen in Fig. 3, if the ascending lumbar vein or high cross-pelvic collateral is visualized, the occlusion most likely is at the level of the common iliac vein. If the ascending lumbar veins or iliolumbar veins are not visualized and the cross-pelvic collateral is low in the region of the pubic area, occlusion of the common and external iliac veins is likely.

Variations of the normal pattern secondary to the injection technique were occasionally noted. Flow in the saphenous venous system and the deep venous system can be seen if the tourniquets are not applied

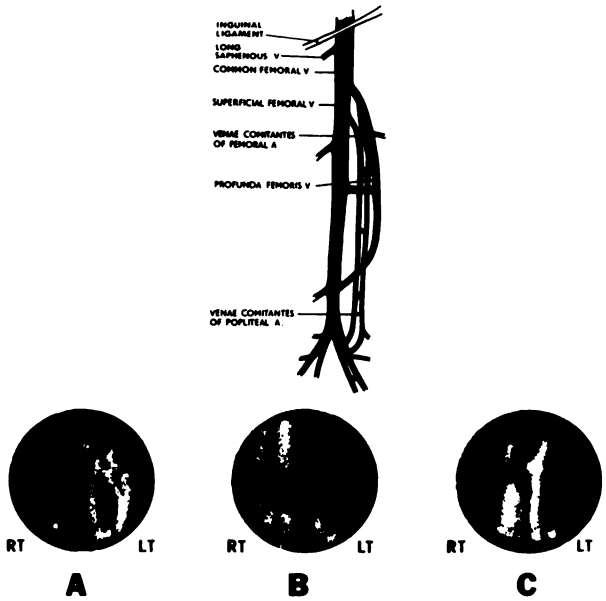

FIG. 2. Abnormal flow patterns in thigh due to obstruction of superficial femoral vein. (A) Bilateral occlusion of superficial femoral veins. No flow was visualized on right. Collateral flow in saphenous (medial) and profunda femoris veins (lateral) was seen on left. (B) Bilateral occlusion of superficial femoral veins with extensive collateral. (C) Bilateral superficial femoral occlusion with collateral flow. Saphenous vein is seen on left.

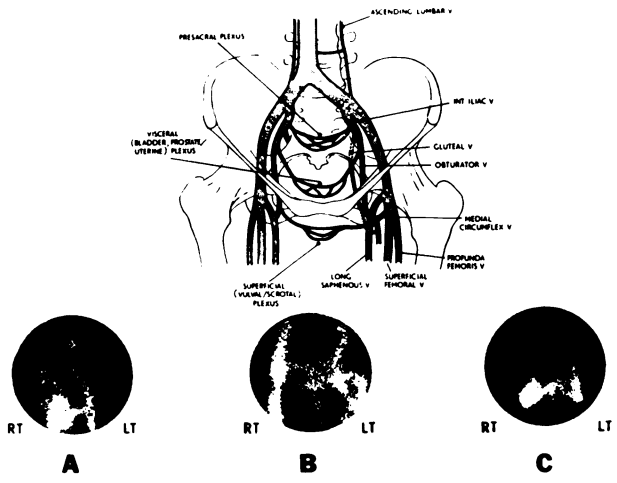

FIG. 3. Abnormal flow patterns in pelvic venous system. (A) Normal venous pattern on left. On right common iliac is occluded with visualization of both cross pelvic collateral (presacral and visceral plexus) and ascending lumbar veins. (B) Occlusion of both common and external iliac veins on left. Both cross pelvic collateral and collateral flow around obstruction (medial circumflex and obturator veins) are seen. (C) Following injection of right venous system only, total obstruction of common and external iliac veins is seen with collateral flow to left through superficial (scrotal) plexus.

tightly. Differential visualization of the right and left deep venous systems may be caused by unequal injection rates.

In our initial 77 studies, 40 patients were abnormal by both radionuclide venography and Doppler examination, and 37 patients were normal by both methods.

DISCUSSION

The deep venous system of the thigh and pelvis is easily imaged with the technique described. In the patient without venous obstruction, normal flow in the deep venous system is readily visualized from the knee level to the lower vena cava. Following the release of the ankle tourniquets, normal flow in the long saphenous vein is easily documented. When occlusive disease is present, obstruction to flow is noted and the normal anatomic collateral pathways that develop are easily shown.

Previous reports from this laboratory (*4*) have shown a 93% correlation of Doppler examination with contrast venography or operative findings in venous disease involving the popliteal, femoral, and iliac veins. In the current study, radionuclide venography and Doppler examination showed essentially similar findings in all cases studied. In addition, the radionuclide technique allows assessment of the common iliac vein and distal vena cava. It is, however, possible that small intraluminal venous thrombi which cause no disturbance in flow would be missed by both techniques.

Although we have had no experience with labeled fibrinogen detection of venous thrombi, studies by others (*2,3*) have shown the effectiveness of this technique in detecting thrombosis in the deep veins of the legs. Whether radionuclide venography will prove to be as sensitive as this technique is unknown. However, the pelvic veins (i.e., common femoral, iliac, and vena cava) which are not easily evaluated with tagged fibrinogen are readily studied by radionuclide venography. At present, it would seem that these techniques are complementary rather than competitive.

Radionuclide venography is rapid, safe, and well tolerated by patients. It can be used as a screening test for occlusive venous disease and is quite suitable for longterm followup of the progression or regression of venous disease.

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