of the actual right-to-left shunt. Since the superior vena cava normally carries about one third of the total systemic venous return, a left and right superior vena cava each carry about one sixth of the total (*6*). With our patient breathing 100% oxygen, a 15–20% right-to-left shunt was calculated, which agrees well with one sixth of the total systemic venous return. Furthermore, our case report stresses the importance of a second injection in the contralateral arm in case of a strongly suspected right-to-left shunt when the first injection reveals no activity in the systemic circulation.

Following injection into the left arm, the shunt resulted in clearly visible myocardial uptake of the tracer. This implies that Seto et al. (*8*) were not wholly correct in concluding that myocardial visualization on a perfusion lung scintigram requires the presence of a large (>39%) right-to-left shunt and marked increase in coronary blood flow secondary to ventricular hypertrophy. In our opinion, myocardial visualization is also possible in cases with a fractional shunt with a partial anomalous venous drainage to the left atrium.

REFERENCES

1. LAROS CD: Shunts in and over the lungs. *Respiration* 29: 24–39, 1972
2. DE LEVAL MR, RITTER DG, MC GOON DC, et al: Anomalous systemic venous connection. Surgical considerations. *Mayo Clin Proc* 50:599–610, 1975
3. WINTER FS: Persistent left superior vena cava: Survey of world literature and report of thirty additional cases. *Angiology* 5:90–132, 1954
4. VAN TELLINGEN C, VERZIJLBERGEN F, PLOKKER HWM: A patient with bilateral superior and inferior caval veins. *Int J Cardiol* 5:366–373, 1984
5. PARK HM, SMITH ET, SILBERSTEIN EB: Isolated right superior vena cava draining into left atrium diagnosed by radionuclide angiocardiography. *J Nucl Med* 14:240–243, 1973
6. KONSTAM MA, LEVINE BW, STRAUSS HW, et al: Left superior vena cava to left atrial communication diagnosed with radionuclide angiocardiography and with differential right to left shunting. *Am J Cardiol* 43:149–153, 1979
7. RIVERA JV, FICEK MA: Double inferior vena cava and anomalous venous drainage from the left arm. Demonstration by radionuclide angiogram. *Clin Nucl Med* 8:306–308, 1983
8. SETO H, FUTATSUYA R, KAMEI T, et al: Myocardial visualization on a routine perfusion lung scintigram: Relationship to the amount of right-to-left shunt. *Eur J Nucl Med* 8:482–484, 1983

Heterotopic Bone Formation (Myositis Ossificans) and Lower-Extremity Swelling Mimicking Deep-Venous Disease

Joseph A. Orzel, Thomas G. Rudd, and Wil B. Nelp

University of Washington, Seattle, Washington

A quadriplegic patient with a swollen leg was suspected of having deep-venous thrombosis, and was studied with radionuclide venography (RNV) and contrast venography. Focal narrowing of the femoral vein, seen on RNV, was due to extrinsic compression. Although soft-tissue radiographs were normal, Tc-99m diphosphonate imaging established the diagnosis of early heterotopic bone formation (myositis ossificans), which was responsible for the venous compression. Clinically this inflammatory process can mimic deep-venous thrombosis, and should be considered in evaluating patients at risk for both heterotopic bone formation and deep-venous thrombosis.

J Nucl Med 25: 1105–1107, 1984

Heterotopic bone formation (HBF), or myositis ossificans, is a well-recognized but poorly understood disease resulting from inflammation and subsequent ossification of muscle and other soft tissues. It is a rare congenital disorder but most commonly occurs after direct muscle trauma or in patients with neurologic damage and paralysis (*1–4*). In our institution, radionuclide venography (RNV) is frequently used to exclude deep-venous obstruction in the paretic patient with a swollen lower extremity. We report a case of early heterotopic bone formation that produced swelling of the thigh through extrinsic compression of the femoral vein. The inflammatory process of HBF, possibly impairing venous return, can result in a clinical presentation closely mimicking deep-venous

Received Feb. 29, 1984; revision accepted June 1, 1984.

For reprints contact: Wil B. Nelp, MD, Div. of Nuclear Medicine, RC-70, University of Washington, Seattle, WA 98195.

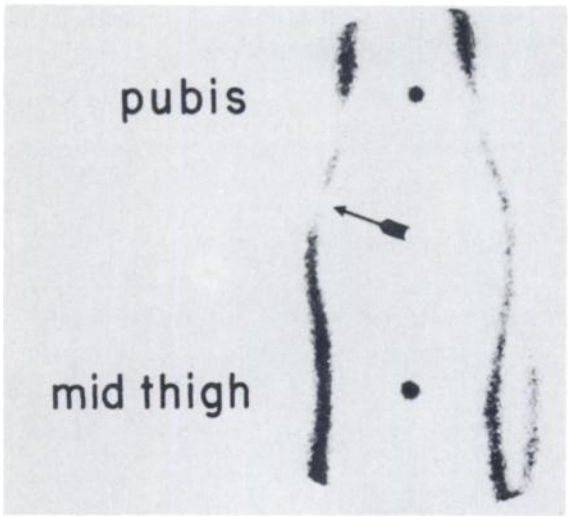

FIG. 1. Radionuclide venogram showing narrowing in right femoral vein (arrow). Narrowing in inguinal area bilaterally is thought to be due to bilateral herniorrhaphy.

thrombosis. The nature of the RNV abnormality is a clue to the correct diagnosis, but imaging with Tc-99m-labeled diphosphonates is necessary for early definitive diagnosis of HBF.

CASE REPORT

Three days after the onset of swelling in his right leg, a 26-yr-old male quadriplegic was admitted for intravenous heparin therapy, with a presumed diagnosis of femoral-vein thrombophlebitis. RNV was performed by injecting 5 mCi of Tc-99m MAA into superficial veins on the dorsum of each foot. Tourniquets were applied at the ankle to optimize visualization of the deep venous system. Abnormal narrowing of the right femoral vein was noted in the proximal thigh (Fig. 1). Bilateral narrowing was also seen in the inguinal areas, felt to be due to constricting scar from surgical repair of bilateral inguinal hernias in childhood. The focal nature of the lesion, and the absence of pathologic collaterals or MAA adherence at the site of narrowing, suggested a nonthrombotic process. Contrast venography was performed for further evaluation, and it confirmed extrinsic compression of the femoral vein at the site of the RNV abnormality (Fig. 2). There was no evidence of thrombus. No soft-tissue calcification was seen on plain radiographs. A three-phase imaging study using 25 mCi of Tc-99m HMDP showed increased vascularity in both proximal thighs, and delayed static images showed marked extraskeletal uptake in both proximal thighs, typical of HBF. The more intense process in the right thigh corresponded to the site of femoral venous compression. On the basis of these studies, heparin was discontinued, and medical treatment for HBF was instituted with oral etidronate disodium.

DISCUSSION

Early HBF must be considered in the differential diagnosis of swollen lower extremities, especially in paretic and traumatized patients. Since these patients are also at increased risk of developing deep-venous thrombosis, RNV may be utilized in their evaluation. RNV has been shown to be excellent for the deliniation of deep-venous occlusion of the lower extremities, showing good correlation with the Doppler examination and contrast venography and having a sensitivity of >90% (*5*). Because of its limited resolution, however, RNV cannot distinguish early or nonoccluding

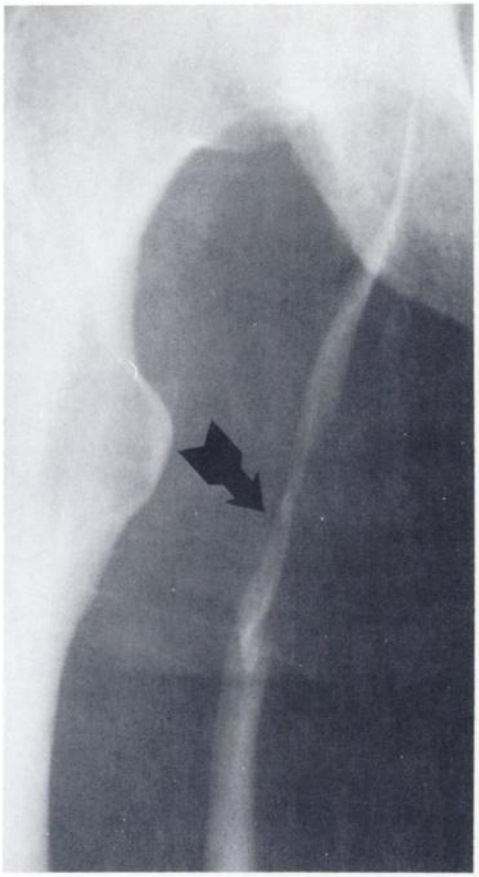

FIG. 2. Contrast venogram demonstrating extrinsic compression of right femoral vein in narrowed portion noted on RNV (arrow). No soft-tissue calcification is seen.

intravascular thrombus from extrinsic compression, which can occur from a variety of causes (*6*). In this case, delayed MAA adherence and the absence of pathologic collaterals suggested extrinsic compression as the cause of the RNV abnormality; nevertheless, the study was cautiously interpreted and contrast venography was performed to exclude clot formation.

HBF may contribute to lower-extremity swelling, through impairment of deep-venous return, and this factor must be considered in evaluating RNV in patients at significant risk for both thrombophlebitis and HBF. Alternatively, a normal RNV in this patient population should alert the nuclear medicine physician to the possibility of early HBF as the cause of extremity swelling, and suggest the use of Tc-99m diphosphonate imaging. As this case illustrates, the diphosphonate study will be abnormal early in the course of HBF and will allow diagnosis and medical treatment well in advance of radiographic changes (*7*). One practical approach for evaluating patients at risk for both HBF and deep-venous thrombosis is to perform the RNV with a Tc-99m bone-imaging agent, followed by immediate blood-pool and delayed soft-tissue images. We have used this approach successfully in our institution.

The pathogenesis and mechanism of bone formation and uptake of diphosphonates in patients with HBF remain obscure (*2,8,9*). Yaghmai has demonstrated that the heterotopic bone lesion is hypervascular initially, then shows serially diminishing blood flow as maturation occurs (*10*). There is also less relative diphosphonate uptake by the HBF process with maturation. These observations have significant implications, since surgical intervention is best deferred until the process is metabolically less active. Thus ra-

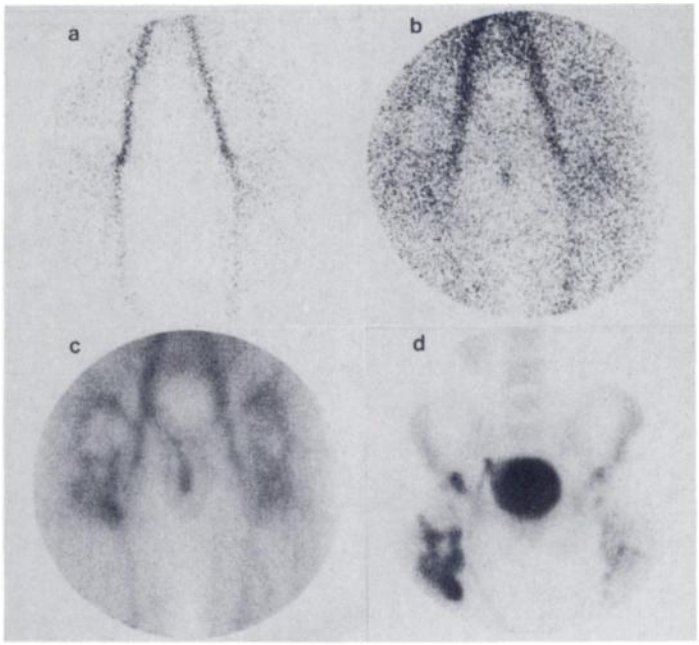

FIG. 3. Three-phase bone study. First-pass radionuclide arterial flow (3a and b) and blood-pool image (3c) show hyperemia in proximal thighs. Three-hour delayed static image demonstrates HBF in both proximal thighs (3d).

dionuclide imaging with Tc-99m bone agents is probably the best method of monitoring this disease.

REFERENCES

1. SMITH R: Myositis ossificans progressiva: A review of current problems. *Semin Arthritis Rheum* 4:369-380, 1975
2. ROSSIER AB, BUSSAT P, INFANTE F, et al: Current facts on para-osteo-arthropathy (PAO). *Paraplegia* 11:36-78, 1973
3. ROBERTS PH: Heterotopic ossification complicating paralysis of intracranial origin. *J Bone Joint Surg* 50B:70-77, 1968
4. MOLLOY JC, MCGUIRK RA: Treatment of traumatic myositis ossificans circumscripta; use of aspiration and steroids. *J Trauma* 16:851-857, 1976
5. NELP WB, LARSON SB, HAMILTON GW: Radionuclide venography. In *Nuclear Cardiology*. Mason DT, Berman DS, eds. New York, Grune and Stratton, 1980, Chap. 15
6. YAO JST, HENKIN RE, CONN J, et al: Combined isotope venography and lung scanning. *Arch Surg* 107:146-151, 1973
7. SUZUKI Y, HISADA K, TAKEDA M: Demonstration of myositis ossificans by ^{99m}Tc pyrophosphate bone scanning. *Radiology* 111:663-664, 1974
8. MILLER LF, O'NEILL CJ: Myositis ossificans in paraplegics. *J Bone Joint Surg* 31A:283-294, 1949
9. URIST MR, NAKAGAWA M, NAKATA N, et al: Experimental myositis ossificans. *Arch Pathol* 102:312-316, 1978
10. YAGHMAI I: Myositis ossificans: Diagnostic value of arteriography. *Am J Roentgenol* 125:811-816, 1977