

# Significance of the Site of Injection in Unexpected Right-to-Left Shunting

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**Lung perfusion scintigraphy, with Tc-99m MAA injected into a left antecubital vein, revealed extensive uptake in the myocardium, kidneys, spleen, thyroid, and brain. After a right antecubital injection, a normal pulmonary perfusion pattern was found. This finding is specific for right-to-left shunting due to anomalous systemic venous drainage into the left atrium.**

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Technetium-99m MAA is the most widely used agent for pulmonary perfusion scintigraphy. After an antecubital vein injection, the MAA is rapidly cleared by the pulmonary arterioles and capillaries in a pattern dependent upon the pulmonary blood flow. In normal subjects, only about 2% of the activity is found in the systemic circulation. When MAA diameter is within normal limits, increased organ uptake is caused by right-to-left shunting where the pulmonary capillary network is bypassed.

We recently studied a young adult with an uncommon right-to-left shunt due to a persistent fetal left superior vena cava draining into the left atrium, and a normal systemic venous drainage into the right atrium.

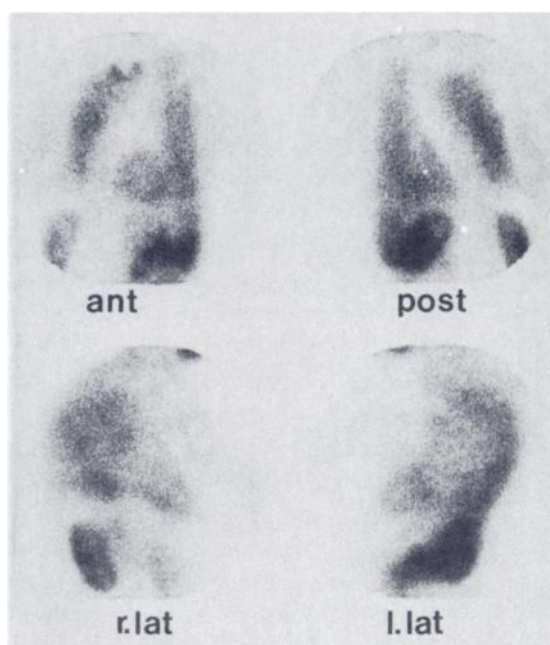
## CASE REPORT

A 23-yr-old man was admitted to our institution because of chest pain and dyspnea. At 3 yr of age he presented with frequent lower respiratory tract infections, cyanotic spells, and retarded growth. Cardiac catheterization revealed persistent fetal left superior and left inferior venae cavae draining into the left atrium and right superior and inferior venae cava drainage into the right atrium, and a large ostium primum atrial septal defect. A 70% left-to-right shunt and a 30% right-to-left shunt was calculated. At cardiac surgery, performed at the ages of 12 and 17 yr, these findings were confirmed. The atrial septal defect was closed with a Dacron patch and the small left inferior vena cava was ligated. At the age of 19 yr a spondylodesis of the first thoracic to second lumbar vertebrae was performed because of severe kyphoscoliosis.

The patient was doing well until 8 days before admission, when right lateral chest pain and dyspnea developed gradually. The symptoms subsided within a few hours, but returned on the day of admission. On physical examination there was a clear chest and a rectal temperature of 36.8°C. The heart was regular, with no murmurs. The chest radiograph showed dextroposition of the heart

due to severe kyphoscoliosis. The lungs were clear, and arterial blood gases were within normal limits.

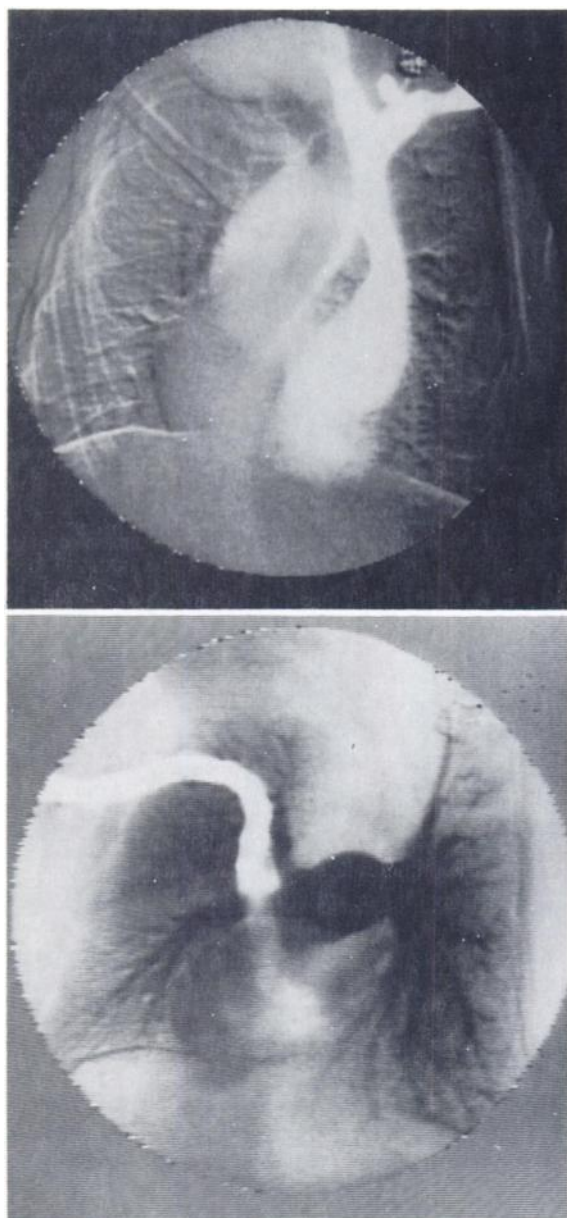
A diagnosis of pulmonary embolism was considered. Because the patient's medical records were not available on the day of admission, we were not aware of the anomalous systemic venous drainage (ASVD). The lung perfusion scintigram was obtained after injection of 2 mCi (74 MBq) Tc-99m MAA into a vein in the left antecubital fossa. The images showed uneven distribution of the tracer in both lungs. Myocardial activity was clearly visualized



**FIG. 1.** Tc-99m MAA images of lungs after i.v. injection in left antecubital fossa. Images show uneven distribution of tracer in both lungs. Due to right-to-left shunting, myocardial, spleen, kidney, and thyroid uptake is clearly visible.

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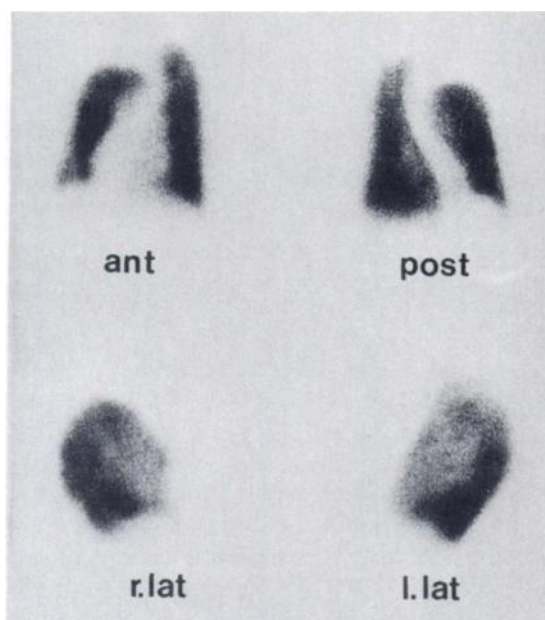
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**FIG. 2.** Digital subtraction angiography following injection in left arm reveals persistent left superior vena cava draining into left atrium (upper). A small hepatic vein is connected to left superior vena cava. Following injection in right arm, a right superior vena cava draining into right atrium is shown (lower). From right ventricle blood passes through normal pulmonary circulation. (Reprinted with permission of Elsevier Biomedical Press B.V.).

in the region of the left-sided heart. There was also significant accumulation of activity in the kidneys, spleen, thyroid, and brain, confirming the presence of a large right-to-left shunt (Fig. 1). The radiochemical purity of the Tc-99m MAA was more than 99%.

Digital subtraction angiography of each major systemic vein, following injection of the contrast material into the same vein, revealed a persistent fetal left superior vena cava draining into the left atrium, and a hepatic vein connecting with the vena cava (Fig. 2, upper). Blood from the left atrium passed through the left ventricle into the systemic circulation. Following injection into a right antecubital vein, the right superior vena cava was seen draining into the right atrium (Fig. 2, lower). From the right



**FIG. 3.** Tc-99m MAA images of lungs after i.v. injection in right antecubital fossa show normal distribution of tracer. (Reprinted with permission of Elsevier Biomedical Press B.V.).

ventricle blood passed through a large pulmonary trunk into the pulmonary circulation. No filling defects were observed, hence the diagnosis of pulmonary embolism was abandoned.

A lung perfusion scintigram, obtained after injection of Tc-99m MAA in the right arm, revealed a normal distribution pattern in both lungs with no sign of a right-to-left shunt (Fig. 3). The chest pain and dyspnea remained unexplained but subsided gradually within 2 days.

#### DISCUSSION

A shunt in or over the lungs may be defined as a normal or abnormal passage in between two vessels or vascular areas, which bypasses either a capillary bed, a heart pump, or both (1). Confining the definition to right-to-left shunts, one should add "carrying desaturated blood to saturated blood". Pathological right-to-left shunts may be distinguished in arterioarterial shunts (patent ductus arteriosus), arteriovenous shunts (arteriovenous fistula), and venovenous shunt types (Liebow shunts, portopulmonary, and lung sequestration shunts).

Anomalous systemic venous drainage into the left atrium represents a very uncommon type of right-to-left shunting. Only ten cases with the form of ASVD presented in this report have been described, and to our knowledge ours is the third case diagnosed during life to appear in the literature (2,3). The anatomical features have been extensively elucidated in a separate report (4). The significance of ASVD into the left atrium depends on the presence and severity of additional cardiac defects. Recognition of anomalous venous drainage is important, as such a condition may act as an aggravating factor in congenital heart disease and it may affect the results of cardiac surgery.

Radionuclide imaging is an established tool for the detection and estimation of right-to-left shunts by measuring the percentage of systemic accumulation of macroaggregated albumin or microspheres after intravenous injection (5-7). In our patient, the percentage of activity in the systemic circulation reflects the total left superior vena caval venous return. Since no mixing of venous blood occurs in the atria, quantification of the extrapulmonary activity following a left-arm injection will result in an overestimate

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.

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

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**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.**

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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

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