Radionuclide Venography and Lung Scanning: Concise Communication

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In 102 patients suspected of pulmonary embolism, we have assessed the ability of a radionuclide (emission) venogram to complement the pulmonary perfusion scintigram in establishing a diagnosis. The efficacy was compared using decision analysis and Bayes's theorem. Two criteria for a positive test were compared: Criterion 1—the test is positive if the lung scan a) indicates a high probability of pulmonary embolus, or b) is abnormal but indeterminate for pulmonary embolus; Criterion 2—the test is positive a) if the lung scan indicates a high probability of pulmonary embolus, or b) if the emission venogram is positive in a patient with a lung scan considered abnormal but indeterminate for pulmonary embolus. The use of Criterion 2 decreased the sensitivity from 100% to 95% and increased the specificity from 74% to 93%. We conclude that a simultaneous emission venogram assists in improving the specificity, accuracy, and the predictive value of a standard pulmonary perfusion study in the diagnosis of pulmonary embolus.

J Nucl Med 20: 291–293, 1979

That pulmonary embolus continues to be a problem of enormous magnitude and frequency is attested to by estimates that as many as 600,000 patients in the United States suffer pulmonary emboli each year with an annual mortality of over 100,000 (*1-3*), and that pulmonary embolism is the sole, or a major contributory, cause of death in 15% of hospitalized adult patients (*3*). Prognosis is excellent following diagnosis and early and appropriate therapy (*4,5*).

The diagnosis of pulmonary embolic disease is not made as often as it should be, despite the availability of radionuclide lung scanning and selective pulmonary angiography. Over two thirds of all emboli occur without clinical recognition, and even when embolism is considered, the diagnostic accuracy by clinical examination is at best 50% (*2*). The pulmonary perfusion scan, which lacks specificity under a variety of circumstances, is one of the most frequently applied tests. Addition of the xenon-133 ventilation study results in increased specificity but is not always possible in patients with pulmonary emboli (*6-7*). The relationship of deep-vein thrombosis to pulmonary embolus (*8-9*), the experience with radionuclide (i.e. emission) venography (*10*), and reports of combined emission venography and lung scanning (*11,12*) led us to evaluate the efficacy of combining the emission venogram with a pulmonary perfusion study when pulmonary embolus is suspected.

MATERIALS AND METHODS

One hundred and two patients with the provisional diagnosis of pulmonary embolus (82 patients) or deep-vein thrombosis (20 patients) were studied

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Received July 10, 1978; revision accepted Dec. 4, 1978.

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by simultaneous emission venography and pulmonary scanning. Forty-seven of these patients were serially studied on two to four occasions. Emission venography was performed as described by Henkin et al. (*10*) following the injection of 1 mCi of Tc-99m-labeled human albumin microspheres into each dorsal pedal vein.

Perfusion lung scans (four to six views) were obtained and interpreted in conjunction with chest radiograph as: a) high probability of pulmonary embolus (multiple segmental and/or lobar perfusion defects seen); b) indeterminate abnormal (nonsegmental, equivocally segmental, or subsegmental defects seen, or abnormalities limited to radiodensities on chest roentgenogram); or c) negative (no perfusion defects visible). Emission venograms were interpreted as abnormal if one of the following criteria was met: a) venous occlusion with or without collaterals; b) intraluminal defects in iliofemoral segment with stasis distal to the partially occluded segment.

The final clinical diagnosis of pulmonary embolus was made retrospectively 9-40 mo after the initial episode if at least one of the following criteria were met: a) perfusion lung scan interpreted as indicating high probability of pulmonary embolus, b) improvement or resolution of perfusion abnormalities on serial studies, or c) hospital course and follow up consistent with diagnosis of pulmonary embolus.

The diagnostic efficacy of the perfusion lung scan alone and combined with the radionuclide venogram was compared using a decision matrix (*7,13*) and Bayes's theorem. The criteria for a positive radionuclide test result were: Criterion 1—if the lung scan was interpreted as indicating high probability for pulmonary embolus or abnormal but indeterminate for pulmonary embolus; or Criterion 2—if the lung scan indicated high probability for pulmonary embolus, or if the emission venogram was positive in a patient with lung scan abnormal but indeterminate for pulmonary embolus.

RESULTS

The results of the combined radionuclide venography and lung scan in 102 patients are summarized in Table 1 and are compared with the retrospective final clinical diagnosis. Comparison of parameters of efficacy of radionuclide study Criterion 1 of Criterion 2 in the diagnosis of pulmonary embolus is presented in Table 2. Use of Criterion for interpretation resulted in a sensitivity of 100%, a specificity of 74%, an accuracy of 86%, and a predictive value of 77%. Use of Criterion 2 for interpretation decreased the sensitivity to 95%, increased the specificity to 92%, increased accuracy to 94%, and gave a predictive value of 92%.

A final diagnosis of pulmonary embolus was made in 39 of the 82 patients initially suspected clinically of having pulmonary embolus, and in nine of the 20 patients initially suspected clinically of having thrombophlebitis. Seventeen of the 20 patients suspected of thrombophlebitis had a positive venogram. Thirty-six of the 39 patients who were clinically suspected of pulmonary embolus and proved to have pulmonary embolus also had thrombophlebitis, although it was clinically suspected in only eight of these patients.

DISCUSSION

The pulmonary perfusion scan provides the physician with a safe, simple, effective, sensitive method of evaluating the integrity of pulmonary

TABLE 1. RESULTS OF THE INITIAL RADIONUCLIDE VENOGRAM AND LUNG SCAN IN 102 PATIENTS COMPARED WITH THE FINAL CLINICAL DIAGNOSIS*

	Pulmonary embolus		
	Present	Absent	No.
Venogram + Lung scan +	37	0	37
Venogram + Lung scan −	8	11	19
Venogram − Lung scan +	5	1	6
Venogram − Lung scan −	2†	38	40
	52	50	102

* The final clinical diagnosis was made retrospectively primarily from clinical criteria (see Materials and Methods).

† Lung scan interpreted as low probability for pulmonary embolus.

TABLE 2. EFFICACY OF PULMONARY PERFUSION STUDY ALONE OR IN COMBINATION WITH RADIONUCLIDE VENOGRAPHY IN PULMONARY EMBOLUS

	Criterion 1*	Criterion 2†
No. patients	102	102
Prevalence	0.47	0.47
Sensitivity	1.00	0.95
Specificity	0.74	0.92
Accuracy	0.86	0.94
Predictive Value	0.77	0.92

* High probability for pulmonary embolus or indeterminate abnormal lung scan considered a positive test

† High-probability lung scan or indeterminate abnormal lung scan with an abnormal radionuclide venogram considered a positive test

blood flow (*6,14*). Its application as a screening test for acute pulmonary embolism represents one of the major contributions of nuclear medicine in the past decade. The frequency of its use is an indication of its utility and the diagnostic void it has filled. Although a sensitive test for pulmonary embolus, the lung scan is less than ideal in specificity. Serial scanning increases the accuracy of diagnosis of pulmonary embolism: in the absence of other reversible pathologic conditions, a changing perfusion pattern provides confirmatory evidence of pulmonary embolism (*15,16*) and a fixed pattern is unlikely to represent recent pulmonary emboli. With concomitant chronic obstructive lung disease, bronchial asthma or congestive heart failure, the lung scan alone was effective in ruling out the diagnosis of pulmonary embolus in fewer than 20 of 100 patients. Recognition of deep-vein thrombosis by objective means could render this diagnostic difficulty less formidable (*17*).

Current or prior venous disease is a well-recognized prelude to pulmonary embolism. Sevitt and Gallagher (*8*) found deep-vein thrombosis in all of the patients who suffered fatal pulmonary embolus. Kakkar et al. (*9*) found pulmonary embolism only when clots were demonstrated by radiofibrinogen in the deep veins. In the pulmonary embolism trial experience with urokinase, 54% of the patients were found to have clinical evidence of venous disease (*18*). Most of the thromboemboli arise from the lower extremities.

The clinical diagnosis of thrombophlebitis is difficult. Not only are there no clinical signs or symptoms referable to limbs in half of the patients with extensive thrombosis, but a third of the patients with a positive clinical diagnosis have no disease in the deep veins on contrast venography (*18*). It is essential, therefore, that the diagnosis of venous thrombosis be confirmed by objective means. A number of studies have established the accuracy of emission venography compared with contrast venograph (*4,10,19*). The emission venogram is a safe, simple, nonpainful, reproducible test that may be performed sequentially. The addition of emission venography at the time of a lung-perfusion study provides accurate information and may be performed serially to evaluate temporal changes. Demonstration of venous disease along with an abnormal indeterminate lung-perfusion study greatly increases the likelihood of pulmonary embolus and is particularly useful in patients with chronic obstructive lung disease or congestive heart failure, or in those patients who cannot tolerate ventilation studies. In the present study all patients with a positive venogram and high-probability lung scan had a final diagnosis of pulmonary embolus; conversely all patients with a negative venogram and negative or indeterminate abnormal lung scan had the final diagnosis of no pulmonary embolus. In nondiagnostic pulmonary perfusion studies, a simultaneous emission venogram assists in improving the specificity of the diagnosis of pulmonary embolus.

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