Utilization of Lung Scans by Clinicians

Nicholas Frankel, R. Edward Coleman, David B. Pryor, H. Dirk Sostman, and Carl E. Ravin

Departments of Radiology and Medicine, Duke University Medical Center, Durham, NC; and Department of Radiology, Yale University Medical Center, New Haven, Connecticut

To determine the effect of clinical assessments and lung scan results on the management of patients, we studied 566 consecutive patients referred for lung scans because of suspected pulmonary embolism. Prior to the lung scan, the clinician was asked to estimate the probability of pulmonary embolus. Two or three days later the physician was contacted to determine how the patient was managed. The results of the lung scan strongly influenced patient management. Patients with high probability lung scans were treated for pulmonary embolism regardless of the clinical pretest estimate. Low and intermediate probability lung scans resulted in most patients not being treated for pulmonary embolism and not referred for pulmonary angiography. Only 55 of the 566 patients were referred for pulmonary angiography, and approximately one-half of these patients had lung scans with an intermediate probability for pulmonary embolism.

J Nucl Med 27:366–369, 1986

Diagnosing pulmonary embolism (PE) is difficult. The presence of PE can be confirmed by pulmonary angiography, but the risk of the procedure, albeit small (*1*), often makes clinicians wary of using it. The physician's clinical assessment can classify patients into groups with different probabilities of having pulmonary embolism, but the classification is imperfect and often leaves the physician uncertain as to the diagnosis. Similarly, ventilation-perfusion (V/Q) lung scans can also be used to classify patients into groups with differing probabilities of having pulmonary embolism (*2–5*). Classifications based on V/Q scanning are also imperfect (*6–11*) and problems in the interpretation of these studies and in their clinical use occur (*8,9*). Thus, no set of signs, symptoms, or laboratory results other than pulmonary angiography reliably discriminates between all patients with and without the disease.

In the absence of a reliable noninvasive method for determining the presence or absence of pulmonary emboli, one would expect that a procedure such as pulmonary angiography that has a low morbidity (*1*) would frequently be used in diagnosing pulmonary embolism since both the disease and its treatment have substantial morbidity. However, studies have shown that only a minority of patients receiving V/Q scans for suspected pulmonary embolism undergo pulmonary angiography (*12*). Although pulmonary angiography is more frequently performed in patients with inconclusive (intermediate probability or indeterminate) lung scans, even in this subgroup only about one-half will undergo pulmonary angiography (*12*). Furthermore, studies which have evaluated clinical estimates of pulmonary embolism have noted ~ 40% of patients have intermediate pretest estimates (*8,11*). One would expect, if patients have both intermediate pretest estimates and intermediate probability lung scan results, these patients would have pulmonary angiography.

The purpose of this investigation was to determine the effect of physicians' clinical assessments and V/Q scan results on subsequent management of patients suspected of pulmonary embolism.

MATERIALS AND METHODS

The study population consisted of the 566 consecutive patients at our institution who were referred between July 1982 and March 1983 for V/Q scans because of suspected pulmonary embolism. The ordering physician was asked to estimate the clinical probability of the patient's having had a pulmonary embolus as high (80%), medium (20–80%), or low (20%).

Ventilation studies were performed prior to the perfusion study in the posterior projection following administration of 15 mCi (555 MB) of xenon-133 (^{133}Xe).

Received May 6, 1985; revision accepted Oct. 8, 1985.

For reprints contact: R. E. Coleman, MD, Box 3949, Duke University Medical Center, Durham, NC 27710.

The study included single breath, equilibrium and washout images. Perfusion images were obtained with 3 mCi (111 MB) of technetium-99m macroaggregated albumin ([^{99m}Tc]MAA) and included six views. Chest x-rays were obtained within 12 hr of the V/Q study. The V/Q scan was interpreted using criteria similar to Biello et al. (*2,6*) for categorizing the results of the scan as normal, low, intermediate or high probability. Pretest estimates of probability were not known by the radiologist interpreting the study. Both intermediate and indeterminate studies were considered intermediate probability studies.

Two or three days following the V/Q study, the ordering physician was contacted to determine how the patient had been managed. The physician's management was used to define whether the diagnosis of pulmonary embolism was excluded, uncertain or confirmed. Patients were assumed to have the diagnosis of pulmonary embolism excluded if no anticoagulant therapy was administered and the patient was not referred for pulmonary angiography. The diagnosis was considered uncertain if the patient was referred for pulmonary angiography (even if the patient refused to undergo the test). The diagnosis was considered confirmed if the patient was treated with anticoagulants without being referred for pulmonary angiography. Patients with normal lung scans which exclude the diagnosis of PE (*9*), patients with other disorders requiring anticoagulation such as deep venous thrombosis, and patients considered too sick to undergo pulmonary angiography were excluded from analysis of the management patterns.

RESULTS

For the 566 patients referred for V/Q scans because of suspected pulmonary embolism, clinical pretest estimates of the probability of pulmonary embolism and the lung scan results are shown in Table 1. The pretest estimates were of low probability in 201 patients, medium probability in 264 patients and high probability in 101 patients. V/Q scan results were normal in 23, low probability in 399 patients, intermediate probability in 90 patients, and high probability in 54 patients.

TABLE 1
Clinical Pretest Estimates and V/Q Lung Scan Results

Pretest estimates	Lung scan results				
	Normal	Low	Intermediate	High	Total
Low	13	159	24	5	201 (36%)
Medium	8	181	48	27	264 (46%)
High	2	59	18	22	101 (18%)
Total	23 (4%)	399 (71%)	90 (16%)	54 (9%)	

TABLE 2
Patient Management Related to Lung Scan Results and Pretest Estimates*

Pretest estimates	Lung scan results		
	Low	Intermediate	High
Low	152 (RX+ 0†, PA 3, RX− 149)	21 (RX+ 0, PA 8, RX− 13)	3 (RX+ 3, PA 0, RX− 0)
Medium	171 (RX+ 3, PA 9, RX− 159)	44 (RX+ 0, PA 11, RX− 33)	26 (RX+ 23, PA 3, RX− 0)
High	48 (RX+ 0, PA 8, RX− 40)	12 (RX+ 0, PA 10, RX− 2)	18 (RX+ 15, PA 3, RX− 0)

* Patients with normal lung scans, other disorders requiring anticoagulation, or too unstable to undergo angiography excluded.

† RX+ = Patients treated with anticoagulation without referral for pulmonary angiography; PA = Patients referred for pulmonary angiography; RX− = Patients not anticoagulated and not referred for pulmonary angiography.

Among the 543 patients with low, intermediate, or high probability lung scan results, 42 patients had other disorders requiring anticoagulation (primarily deep venous thrombosis) and six patients were considered too unstable to undergo pulmonary angiography. Management assumptions made for the remaining 495 patients are shown in Table 2, classified by the pretest and V/Q scan probabilities of disease. Patients treated with anticoagulation without receiving pulmonary angiography (RX+) were almost exclusively patients with high probability V/Q scans regardless of the clinical estimates; among all RX+ patients, 93% (41/44) had high probability scans. Patients for whom the diagnosis was uncertain and referred to angiography (PA) were found in small numbers in many subgroups, but 53% (29/55) were in patients with intermediate lung scans. Although 38% (29/77) of all patients with intermediate lung scans were referred for pulmonary angiography, 83% (10/12) of patients with high clinical pretest estimates and intermediate lung scans had pulmonary angiography. The patients assumed not to have pulmonary embolism (RX−) were 94% (348/371) of all patients with low probability V/Q scans and 62% (48/77) of all patients with intermediate V/Q scans. No patient with a high probability V/Q scan was assumed not to have pulmonary embolism.

The ability of the V/Q scan to influence management is further illustrated in Fig. 1. In the figure the proportion of patients treated for pulmonary embolism, referred to pulmonary angiography or not treated for pulmonary embolism are categorized by the V/Q result and further classified by the clinical pretest estimate. Figure 1 illustrates that the results of the V/Q scan

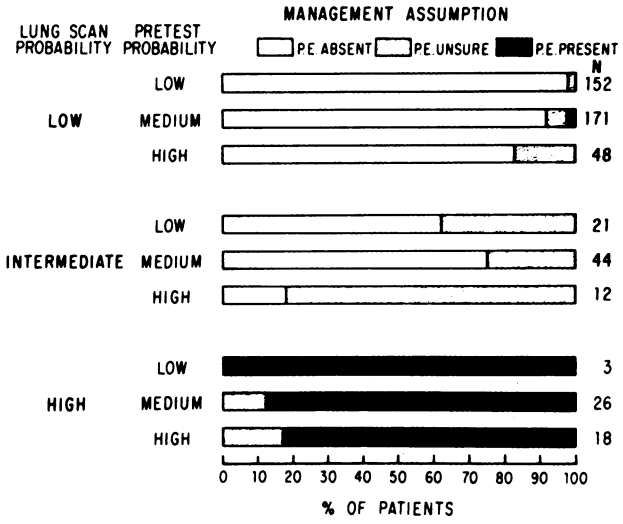

FIGURE 1
Effect of lung scan result and pretest estimates on patient management. PE Absent patients were not treated for pulmonary embolism, PE Unsure patients were referred to pulmonary angiography, and PE Present patients were treated for pulmonary embolism. Clear association of lung scan result with patient management is demonstrated

dictated management strategies. High probability V/Q scans resulted in most patients receiving anticoagulation regardless of the clinical estimate of probability of pulmonary embolism. Low and intermediate probability lung scans resulted in most patients not receiving anticoagulation except that considerable uncertainty existed for patients with high pretest estimates and intermediate V/Q scan results.

Among the 55 patients referred for pulmonary angiography, satisfactory studies were obtained in 51 patients (three patients refused and one study was technically inadequate). The results classified by pretest estimates and V/Q scan results are shown in Table 3. The clinical pretest estimate did not appear to be related to the results of the angiogram, whereas the V/Q scan was able to a limited extent to separate patients likely or unlikely to have a positive angiogram.

DISCUSSION

The present study demonstrates that lung scan interpretations strongly influence patient management. Patients with high probability scans invariably receive anticoagulation without further study while most patients with low or intermediate probability scans are not treated and do not undergo pulmonary angiography. Our results extend the observations of the Herlev Hospital study group (*8*). In that study, lung scan results in 60 patients strongly affected clinical post-test probabilities of disease although the initial interpretation of the lung scan was biased by the clinical assessment making it difficult to discern the contribution of the lung scan

TABLE 3
Patients with Pulmonary Angiograms

Pretest estimates	Lung scan results			
	Low	Intermediate	High	Total (%)
Low	0/3*	4/8	—	4/11 (36)
Medium	1/9	4/10	1/3	6/22 (27)
High	1/7	3/8	3/3	7/18 (39)
Total (%)	2/19 (11)	11/26 (42)	4/6 (67)	

* Positive pulmonary angiogram/total in group.

by itself to post-test estimates of the likelihood of pulmonary embolism.

Saenger et al. (*13*) compared two methods, logistic regression and entropy minimax pattern detection (*14*), to evaluate the efficacy of lung scans in 2,023 patients. They found that the lung scan results significantly influenced the referring physician's consideration of the probability of pulmonary embolism. Furthermore, the lung scan results correlated with the therapeutic management the patient received. The relative contribution of clinical estimates of pulmonary embolism and lung scan results on the physician's decision to perform pulmonary angiography or to administer or withhold anticoagulation was not examined.

Considering the well-described uncertainty in the interpretation of V/Q scans, the results of our study suggest that physicians are using the lung scan to affect patient management differently from what we had anticipated. Management appears to have been dictated primarily by the V/Q scan results without considering the importance of the pretest estimate of disease (*15*) or uncertainty in V/Q scan interpretation. Simply stated, high probability scans are more likely to be falsely positive in patients with low pretest estimates compared with patients with high pretest estimates. Conversely, low probability scans are more likely to be falsely negative in patients with high pretest probability compared to patients with low pretest clinical estimates. In our study, the clinician appears to have had little faith in clinical estimates. While no single clinical symptom or sign is both sensitive and specific for pulmonary embolism, previous studies have shown that estimates of the likelihood of pulmonary embolism can be based on groups of signs and symptoms (*10,16*). In the patients who had pulmonary angiography in our study, the pretest estimate of pulmonary embolism did not predict patients who had positive pulmonary angiograms (Table 3). Thus, it appears that reliable clinical pretest estimates of pulmonary embolism were difficult to make for physicians participating in our study. This may reflect the difficulty in combining many signs and symptoms to produce a single estimate of the likelihood of disease.

Another finding of this study is that pulmonary angi-

ography is infrequently used even when considerable uncertainty exists about the diagnosis. Only 25% of patients (11/44) with medium pretest estimates and intermediate lung scan probabilities were referred for pulmonary angiography. We believe that considerable uncertainty also existed for other groups of patients and yet pulmonary angiography was commonly performed only for patients with high clinical pretest probabilities and intermediate lung scan probabilities. In no other subgroup was the frequency of pulmonary angiography greater than 40%.

The reasons for our findings are unclear and will require further study. The hazards of pulmonary angiography may have been overestimated by the physician or, conversely, the hazards of anticoagulation underestimated. The physicians may have underestimated the uncertainty in lung scan interpretations, particularly in the assumption that low probability scans were equivalent to normal scans. It is also possible that during the initial course of the patient's evaluation, additional clinical information may have been obtained and appropriately used by the physician to modify the estimated likelihood of pulmonary embolism.

ACKNOWLEDGMENTS

The authors thank the physicians at Duke University Medical Center for their cooperation in this study. They also thank Dr. Barbara McNeil and Dr. Roger Secker-Walker for their helpful comments concerning this study. The assistance of Ms. Carolee Osborne and Ms. Linda Wilson in the preparation of this manuscript is greatly appreciated.

This work was supported in part from Research Grants (HL 17670 and HL 07503) from the National Heart, Lung and Blood Institute, (CA 14236) from the National Cancer Institute, (HS 04873) from the National Center of Health Services Research, and the Andrew M. Mellon Foundation.

REFERENCES

1. Mills SR, Jackson DS, Older RA, et al: The incidence, etiologies, and avoidance of complications of pulmonary angiography in a large series. *Radiology* 136:295-299, 1980
2. Biello DR, Mattar AG, McKnight RC, et al: Ventilation-perfusion studies in suspected pulmonary embolism. *Am J Roentgenol* 133:1033-1037, 1979
3. McNeil BJ. A diagnostic strategy using ventilation-perfusion studies in patients suspected for pulmonary embolism. *J Nucl Med* 17:613-616, 1976
4. Carter WD, Brady TM, Keyes JW, Jr, et al: Relative accuracy of two diagnostic schemes for detection of pulmonary embolism by ventilation-perfusion scintigraphy. *Radiology* 145:447-451, 1982
5. Cheely R, McCartney WH, Perry R, et al: The role of noninvasive tests versus pulmonary angiography in the diagnosis of pulmonary embolism. *Am J Med* 70:17-22, 1981
6. Sullivan DC, Coleman RE, Mills SR, et al: Lung scan interpretation: Effect of different observers and different criteria. *Radiology* 149:803-807, 1983
7. Hoey JR, Farrer PA, Rosenthall LJ, et al: Interobserver and intraobserver variability in lung scan reading in suspected pulmonary embolism. *Clin Nucl Med* 5:508-513, 1980
8. Lauritzen T, Bugge PBB: Diagnostic decision process in suspected pulmonary embolism. *Lancet:* 1336-1338, 1979
9. Robin ED: Overdiagnosis and overtreatment of pulmonary embolism: The emperor may have no clothes. *Ann Intern Med* 87:755-781, 1977
10. McNeil BJ: Ventilation-perfusion studies and the diagnosis of pulmonary embolism: Concise communication. *J Nucl Med* 21:319-323, 1980
11. Hull RD, Hirsh J, Carter CJ, et al: Pulmonary angiography, ventilation lung scanning, and venography for clinically suspected pulmonary embolism and abnormal perfusion lung scan. *Ann Intern Med* 98:891-899, 1983
12. Sostman HD, Ravin CE, Sullivan DC, et al: Use of pulmonary angiography for suspected pulmonary embolism: Influence of scintigraphic diagnosis. *Am J Roentgenol* 139:673-677, 1982
13. Saenger EL, Buncher CR, Specker BL, et al: Determination of clinical efficacy: Nuclear medicine as applied to lung scanning. *J Nucl Med* 26:793-806, 1975
14. Gift DA, Schonbein WR, Saenger EL, et al: Application of an information-theoretic method for efficacy assessment. *J Nucl Med* 26:807-811, 1985
15. Griner PF, Mayewski RJ, Mushlin AI, et al: Selection and interpretation of diagnostic tests and procedures—principles and applications. *Ann Int Med* 94:553-600, 1981
16. McNeil BJ, Hessel SJ, Branch WT, et al: Measures of clinical efficacy. III. The value of the lung scan in the evaluation of young patients with pleuritic chest pain. *J Nucl Med* 17:163-169, 1976