Incidence of Pulmonary Embolism in Single Segmental Mismatch on Lung Scanning

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Controversy exists as to whether patients with single segmental mismatch (SSM) on a ventilation/perfusion (VQ) lung scan should be given a low or an intermediate probability of pulmonary embolism (PE). **Methods:** Pulmonary angiography was used to evaluate the incidence of PE in SSM at the authors' institution. From January 1991 to January 1993, 1449 VQ scans were performed. **Results:** With modified Biello criteria, 283 were high probability; 628, low probability; 273, normal; and 273, intermediate probability. Of the intermediate probability scans, 61 had SSM. Forty of these patients underwent pulmonary angiography. Twelve patients had PE in the area of the SSM, giving an incidence of PE of 30%. The risk of PE in SSM in the different lung regions was also analyzed. Twenty-three SSM were in the bases of the lung with a 22% incidence of PE; 17 SSM were either in the midzone or apex with a 41% incidence of PE (p = not significant). **Conclusion:** SSM carries a 30% risk of PE. Accordingly, SSM should be given an intermediate probability of PE and not a low probability of PE.

Key Words: single segmental mismatch; ventilation-perfusion scan; pulmonary embolism

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A single perfusion defect with normal corresponding ventilation, also referred to as a single segmental mismatch (SSM), on a ventilation/perfusion (V/Q) scan has caused some confusion as to whether this pattern represents a low (*1*), intermediate (*2,3*) or even high probability (*4*) of pulmonary embolism (PE). This confusion was evident in the recent publication of the results of the PIOPED trial (*5*). Initially, SSM was assigned a low probability of PE (*5*), but in subsequent publications, it has been reassigned as intermediate probability (*6*).

One possible cause for the confusion may be the limited number of patients reported as having SSM. Catania and Caride (*3*) reported 30 patients with a single perfusion defect, of which 9 patients had SSM. Rosen et al. identified 20 (*2*) patients. In the PIOPED study, there were 28 patients (*6*).

It has also been suggested that the site of any perfusion defects within the lung may indicate a different incidence of PE. Catania and Caride (*3*) found that, in all their patients with a single perfusion defect (n = 15), those perfusion defects in the posterior basal segments had a higher incidence of PE compared with those occurring elsewhere (Table 1).

To elucidate the incidence of PE in patients with SSM further, the authors reviewed the results of pulmonary angiography in all their patients who had SSM on V/Q scan. They also examined whether the site of SSM or the presence of other matching V/Q defects influenced the frequency of PE in these patients.

MATERIALS AND METHODS

Of 1449 V/Q scans performed at the authors' institution between January 1991 and January 1993; 283 (19%) were classified as high; 273 (19%), as intermediate; and 628 (43%), as low probability, with 273 (19%) as normal according to the modified Biello criteria. All scans were viewed by one of two experienced observers (R.Q. and S.P.B.); 61 of the 173 intermediate scans demonstrated SSM or a SSM with additional matching, segmental or greater V/Q abnormality (matching defect) separate to the SSM. A SSM was defined as a solitary peripheral perfusion defect, no larger than one segment, but at least 25% to 100% of the segment in size with corresponding normal ventilation on the V/Q scan. The lung segments were defined according to the segmental anatomy chart of De Nardo and De Nardo (*7*). All patients with SSM had a normal chest x-ray at the site of the abnormality.

The V/Q scan was performed in six views for ventilation and perfusion: anterior, posterior, right anterior oblique, right posterior oblique, left anterior oblique and left posterior oblique. Ventilation was performed using a Technegas generator (Tetley Industries, Sydney, Australia). The perfusion study was performed after intravenous injection of 180 MBq of ^{99m}Tc (ANSTO, Sydney, Australia)-labeled macroaggregated albumin (Du Pont, Sydney, Australia).

Pulmonary angiography was performed from a femoral vein approach using a 5-French pigtail catheter and nonionic contrast. Selective angiography of the right or left pulmonary arteries directed to the regions of abnormality on the V/Q scan was performed. Initial anteroposterior series of films to the region of abnormality on V/Q scan was performed followed by additional oblique or superselective angiograms as indicated. If the area of SSM did not demonstrate PE, then any lung region that demonstrated a matching defect on V/Q scan was examined. One patient underwent pulmonary angiography directed to the region of a matching defect only in which PE was diagnosed. The area of SSM was, therefore, not examined. This patient was excluded

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TABLE 1
Incidence of Pulmonary Embolism in Patients with Single Segmental Mismatch with or without Associated Matching Defect

	PE	No PE	% PE
SSM (total)	12	40	30
SSM	6	25	25
SSM and MD	6	9	67

PE = pulmonary embolism; SSM = single segmental mismatch; MD = matching defect.

from the study group. The angiographic criteria for PE was a demonstrable filling defect in a vessel not smaller than 2 mm, which was visible in at least two images. Pulmonary angiography was used as the "gold standard" for PE.

Of the 61 patients with SSM demonstrated on V/Q scan, 40 underwent pulmonary angiography directed at the SSM and were enrolled in the study. Thirty-eight angiographic studies were performed within 24 hr, 1 within 48 hr and 1 within 72 hr of the V/Q scan.

To determine selection bias, the distribution of risk factors in the enrolled 40 patients was compared with the risk factors in the 21 patients with SSM who did not proceed to pulmonary angiography. Each risk factor (surgery in the preceding 4 wk, cardiac failure, immobilization, malignancy, oral contraceptive use, pregnancy and a history of thromboembolism) was given a score of 1.

In addition, the SSM were classified according to their location in the lung as either involving a basal segment of either lower lobe or one of the remaining nonbasal lung regions. Chest x-rays were obtained in all patients within 24 hr of the VQ scan.

RESULTS

Of the 40 patients (23 female and 17 male; age range 18–23 yr) with SSM or SSM combined with a matching defect, 12 (30%) of patients demonstrated PE at the site of SSM on pulmonary angiography.

Thirty-one patients had SSM alone, of which six demonstrated PE on pulmonary angiography. Nine patients had SSM combined with a matching defect; six of these patients had PE on pulmonary angiography at the site of SSM. Of the patients with a matching defect, seven had radiologic abnormalities in the region of the matching defect. Of these, five (71%) demonstrated PE in the area of SSM. Of the two remaining, who had a matching defect with no associated chest x-ray abnormality, one demonstrated PE at the site of SSM.

Twenty-three defects were located in a basal segment of either lower lobe, and of these, five (22%) were positive for PE. Seventeen segments were in the midzone or upper lobes, of which seven (41%) were positive for PE. There was no significant difference in the incidence of PE depending on site of SSM in the lung ($p = 0.6$).

The patients who were enrolled in the study (i.e., pulmonary angiography was performed) had an average of 1.20 risk factors compared with those who did not undergo pulmonary angiography, 1.43 risk factors. This difference was not significant ($p = 0.7$). In those patients who went on to angiography, the average of risk factors was 1.75 for those with PE and 0.93 for those without. This difference was statistically significant ($p = 0.02$).

DISCUSSION

The SSM on V/Q scan has caused confusion over the significance of the finding. One of the objections to the original PIOPED study was it included the SSM in the low probability category, despite several studies demonstrating that this pattern has an intermediate probability of PE (*2,8*). Subsequently, this was revised with reanalysis of the PIOPED data showing a 36% incidence of PE (10 of 28) studies, which coincided with the incidence of PE in this study group.

In this study, 61 of a total of 273 patients (22%) in the intermediate-probability group demonstrated SSM. Most of these patients went on to pulmonary angiography, as is the authors' departmental policy. In those that did not go on to angiography, there was no significant difference in the average risk factors in the pulmonary angiography group (1.20) and the nonpulmonary angiography group (1.43). This implies that the group that went on to pulmonary angiography were not a substantially at-risk group for PE. In those in whom the area of the SSM was examined by pulmonary angiography, PE was found in 30% (12 of 40), confirming that SSM has an intermediate probability of PE. There was a significant difference in risk factors between patients who had PE on angiography (1.75) and those that did not (0.93). This is not an unexpected result, but as there was a wide variation of risk factors in each group, relying on the risk factors alone would be of little use in defining the presence of PE in the individual patient.

Nine of the 40 enrolled patients had one or more remote matching defects on the V/Q scan. Of these, 7 had radiologic abnormalities corresponding to the matching defect (5 of 7 demonstrated PE at the area of SSM), and 2 had a matching defect with no chest x-ray abnormality (1 of 2 demonstrated PE) (Fig. 1). Although the number here is limited, it is of interest that the scan appearance of a SSM and a matching defect with a corresponding radiologic abnormality may indicate a subgroup of patients at higher risk of PE.

Furthermore, we examined whether the site of SSM, basal or nonbasal influenced the incidence of PE, as had been suggested by Catania and Caride (*3*). Similarly, it was found that SSM occurred more frequently in the basal segments; however no evidence was detected of an increased incidence of PE when the SSM was basal (22%) as opposed to the nonbasally (41%) placed (Fig. 2).

Although these data demonstrate an intermediate risk of PE in SSM, as stated earlier, there has been some confusion as to this risk. Some of the confusion arises from the fact that, in the previous literature, SSM and a single segmental perfusion defect with no reference to ventilation were sometimes treated as similar entities (*1,3*). This ap-

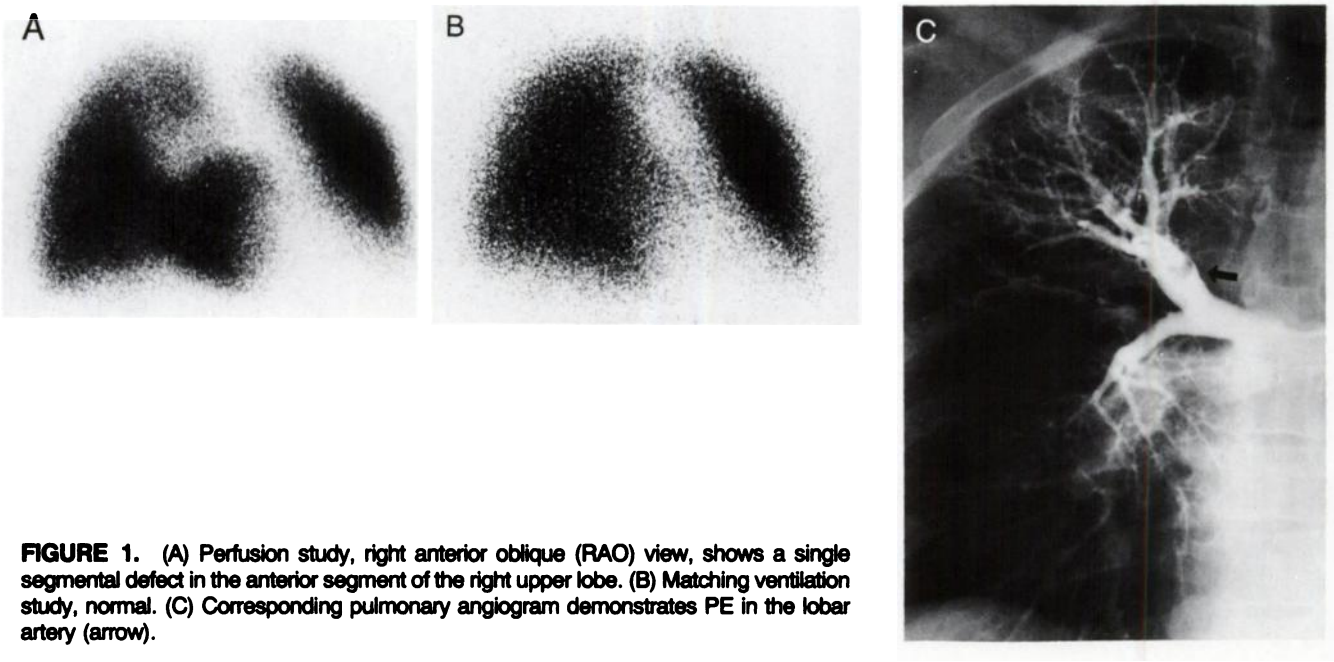

FIGURE 1. (A) Perfusion study, right anterior oblique (RAO) view, shows a single segmental defect in the anterior segment of the right upper lobe. (B) Matching ventilation study, normal. (C) Corresponding pulmonary angiogram demonstrates PE in the lobar artery (arrow).

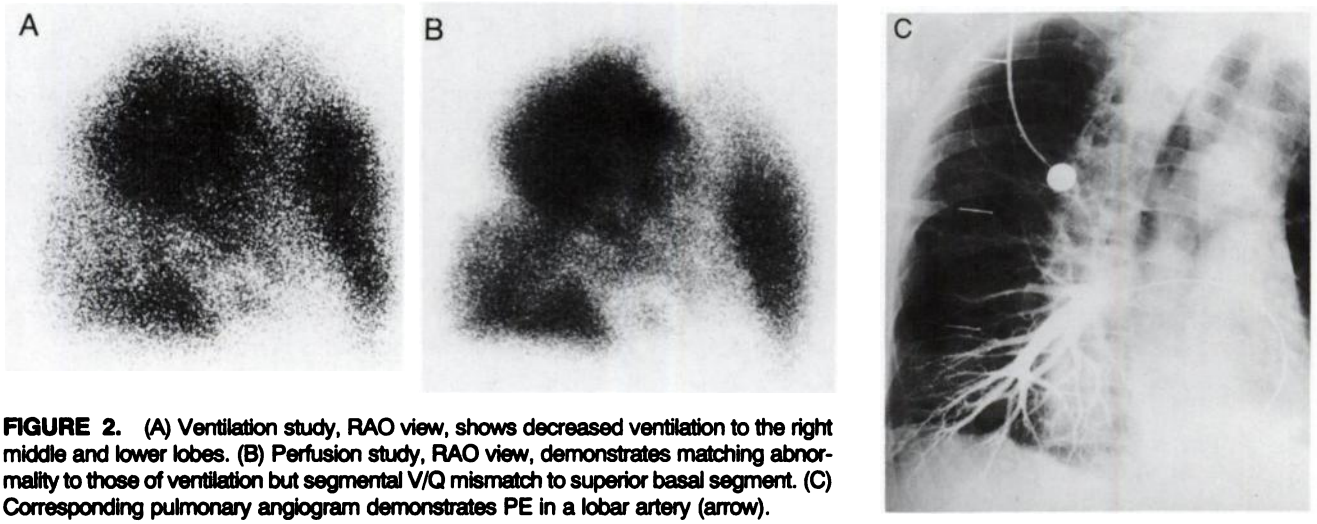

FIGURE 2. (A) Ventilation study, RAO view, shows decreased ventilation to the right middle and lower lobes. (B) Perfusion study, RAO view, demonstrates matching abnormality to those of ventilation but segmental V/Q mismatch to superior basal segment. (C) Corresponding pulmonary angiogram demonstrates PE in a lobar artery (arrow).

proach is able to provide a diagnostic algorithm that would encompass institutions where ventilation imaging was unavailable or difficult to perform or in situations in which the perfusion defect was in a site where adequate ventilation images were not obtained, which may be the case if ^{133}Xe is the ventilation agent. However, with the advances in ventilation imaging, it should now be possible for the ventilation status of most perfusion abnormalities to be ascertained. This produces in effect two possible categories for the single perfusion defect: either matched or unmatched.

In summary, the authors believe that SSM is of intermediate probability for PE and that pulmonary angiography is required for the definitive diagnosis of PE. They also believe that the single perfusion defect should be abandoned as a category in diagnostic algorithms because most patients can have a six-view ventilation image and the ventilation to the segment in question can, in the majority, be assessed.

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EDITORIAL

V/Q Imaging and the Diagnosis of PE: "Can We Shift the Gray to Black and White?"

Imagine you are working in your reading room late one night interpreting a hepatobiliary study. You are looking at a technically excellent examination. One of the "night people" cleaning out your area looks up from work and says, "a nice case of acute cholecystitis, Doc." Impressed, you ask for help on your next case—a V/Q scan—only to get a response suggesting that in no way does such assistance fit as part of his/her job description. In short, the black or white diagnostic ease associated with most hepatobiliary diagnoses has been replaced by the grays which have been part of V/Q scan interpretation for over 25 yr I have been trying to read these studies. In this issue of the *Journal*, Bernard and colleagues (*1*) hope to shift some of the gray into the more definitive black or white zones. If you read this editorial, you will note that I am not sure they have succeeded as well as they might have liked.

This apparently straightforward black-and-white statement is already tinged with gray. In PIOPED, segmental mismatched lesions were defined as small (<25% of a segment), moderate (25%–75% of a segment), or large (>75% of a segment). This terminology was initially formulated by the late Dan Biello and adopted by PIOPED. However, Bernard and colleagues define their SSM as a mismatched lesion confined to a single segment involving 25%–100% of the segment in size. In short, these authors combine what in PIOPED would have been called either a moderate or a large segmental mismatch. Furthermore, the original PIOPED study interpretative criteria stated that only "a single *moderate* mismatched segmental perfusion defect with normal chest roetengenogram" was a criteria for a low probability diagnosis (*2*). It is true that the revised PIOPED criteria reassigned the single moderate mismatch to intermediate probability (*3*). Therefore I conclude that Bernard et al. are confused about the initial PIOPED confusion. In other words, our editorial fruit cart is already getting piled with apples and oranges.

Bernard et al. go on to state that the problem may be the result of the limited number of patients having single segmental mismatches. If, however, we use the authors definition (i.e., a SSM is 25%–100% of a segment) is the PIOPED data base really limited? In fact, there were 28 patients with a single moderate segmental mismatch and 24 who had a single large segmental mismatch. These should be lumped together (as Bernard et al. so lumped) to yield a group of 52 prospectively recruited patients; all of whom had angiograms. Of these, 22 patients (42%) had pulmonary embolism. This is not only a larger group than Bernard et al. analyzed, but the PIOPED data are not troubled by the fact that a large portion of the relevant lesions never came to angiography. In the Australian series, only about two-thirds of the patients with SSM had angiograms. Bernard et al., to their credit, make every effort to show that the risk factors for PE were comparable in the group that had angiograms and those that had not. They overlook only one key variable—clinical suspicion for pulmonary embolism. This is potentially disturbing since it is possible that clinicians may have considered patients who had pulmonary angiograms with more suspicion than patients who did not. Since (in PIOPED) there is a relationship between higher clinical suspicion for PE and the presence of PE, this could be an important variable. Nevertheless, once the jargon is clarified, it seems clear that Bernard et al. and PIOPED agree with the concept that a SSM represents an intermediate probability for PE.

Many of you might wonder how the PIOPED nuclear medicine working group could be so dumb as to initially state that a single moderate segmental mismatch should be called low probability, particularly since Bernard et al. cite two important non-PIOPED papers showing that the SSM "has an intermediate probability of PE." One of these was written in 1976 and contains only three pertinent patients (*4*). The other was published in 1986 by Rosen et al. and is a seminal contribution to the V/Q scan literature about single mismatched lesions (*5*). Let me point out that the initial criteria for scan analysis in PIOPED were developed in 1983 and 1984 and set in concrete at that time. Patient accession to PIOPED began in 1985, and the criteria could not be changed in the middle of the trial. In short, the PIOPED nuclear medicine working group did its best with data then available in that "pre-Rosen" time period. We also knew that the data base in PIOPED would be computerized so that reanalysis would be possible at a later date.

When I look at the figures provided by Bernard et al., I am impressed that I would not interpret the images in the

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