Pulmonary Scan – Reporting Document

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Chapter 1: Introduction

Pulmonary scan refers to the diagnostic imaging procedure that uses ventilation scintigraphy, perfusion scintigraphy or both to evaluate pulmonary disorders.

These procedures are primarily performed to determine whether a perfusion defect is secondary to a ventilation abnormality rather than primarily vascular problem. Inhaled radiopharmaceuticals can map ventilation while dedicated injected pharmaceuticals map perfusion.

Because most mismatched perfusion abnormalities are the result of acute pulmonary emboli, the diagnosis can be made with a reasonably high degree of accuracy. In the PIOPED Trial, the specificity for PE was 97% and PPV was 88%.

Advantages:

- A normal perfusion lung scan virtually excludes PE
- Sufficiently diagnostic when clinical probability and scan "probability" are concordant
- Does not require iodinated contrast

Disadvantages:

- Many combinations of clinical and scan probabilities that are "non-diagnostic" (72% in PIOPED)
- Even high probability scans can be falsely positive
- Scar from prior PE
- Cancer with vascular involvement

Chapter 2: Indications

Most Common:

- To determine likelihood of pulmonary embolism

Less Common:

- Document resolution of pulmonary embolism
- Quantification of differential pulmonary function before surgery for lung cancer
- Evaluation of lung transplants
- Evaluation of congenital heart disease such as cardiac shunts, pulmonary arterial stenosis, arteriovenous fistula and its treatment
- Confirm presence of bronchopleural fistula
- Chronic pulmonary parenchymal disorders like cystic fibrosis
- Evaluation of cause of pulmonary hypertension

Chapter 3: Radiopharmaceuticals

Perfusion

- Tc-99m macro aggregated albumin (MAA)
- I-131 macro aggregated albumin
- Tc-99m human albumin microspheres

Ventilation

Radioactive Gases

- Xe-133
- Xe-127
- Kr-81m

Radioaerosols

- Tc-99m DTPA
- Tc-99m Technegas

Chapter 4: Image Interpretation

(Points to be noted for interpreting Pulmonary Scintigraphy as negative for PE)

Chest X-Ray:

- Chest X-ray reviewed for any abnormality (acute /chronic)
- Acute causes of triple match like atelectasis, pleural effusion or infiltrates noted
- Non segmental defect causes like cardiomegaly, elevated diaphragm and hilar enlargement noted

Ventilation Scintigraphy:

- Homogenous distribution with lesser counts on three phases similar to perfusion scan should appear without significant retention on wash out images in case of Xe-133
- Bases more intense than apex
- Heart defect in left anterior base

Perfusion Scintigraphy:

- Homogenous uniform distribution throughout lung
- Hilar structures should appear photopenic
- Heart as decreased activity at left base
- Spine and sternum attenuate activity at midline
- Effect of gravity- more activity at base
- Free pertechnetate activity

4.1 Normal V/Q Scan with Tc-99m Ventilation:

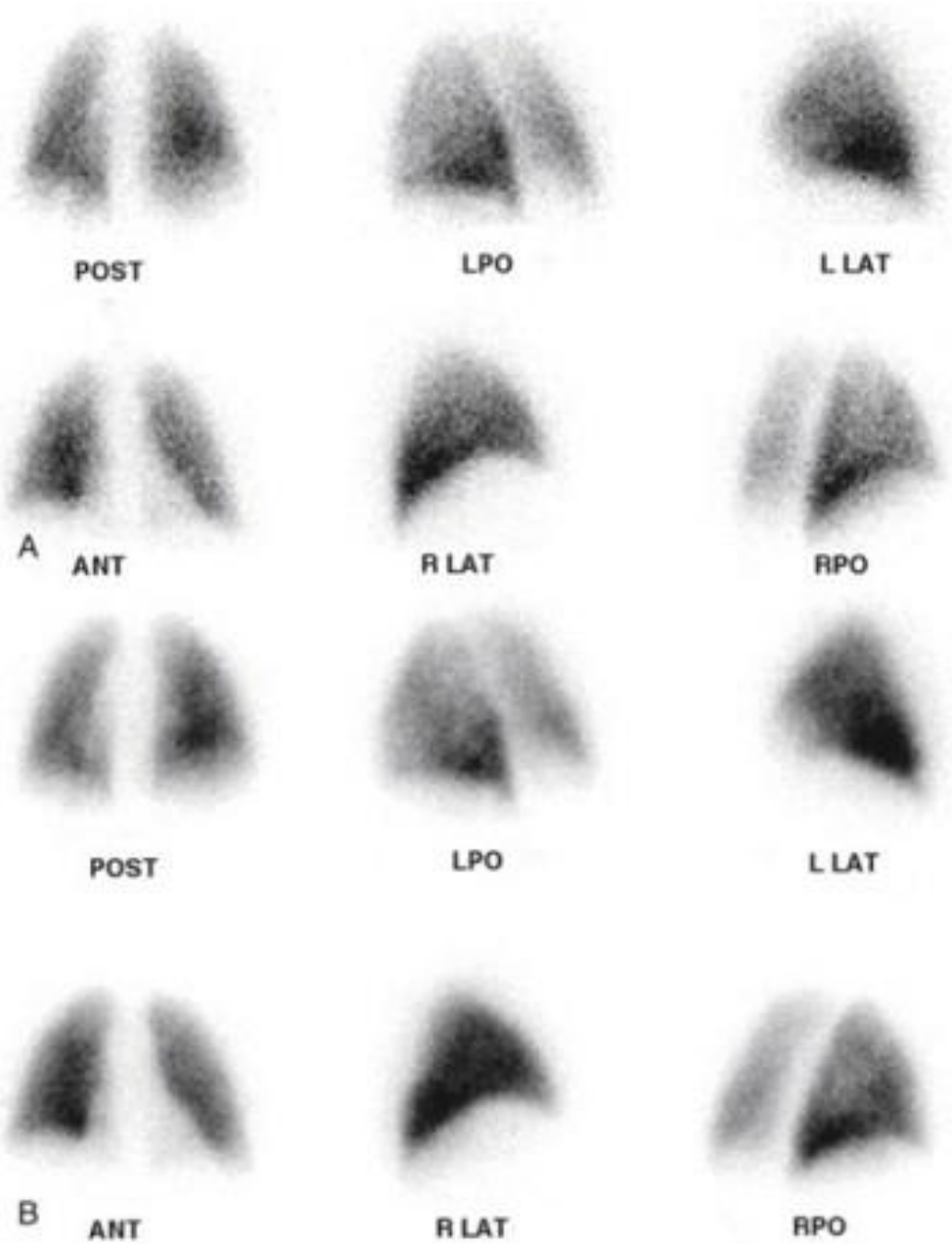


Figure 1: Ventilation (A) and perfusion (B) lung scans show homogeneous radiotracer distribution and the normal gradient of increasing activity in the bases relative to the apices.

4.2 Normal V/Q Scan with Xenon-133 Ventilation:

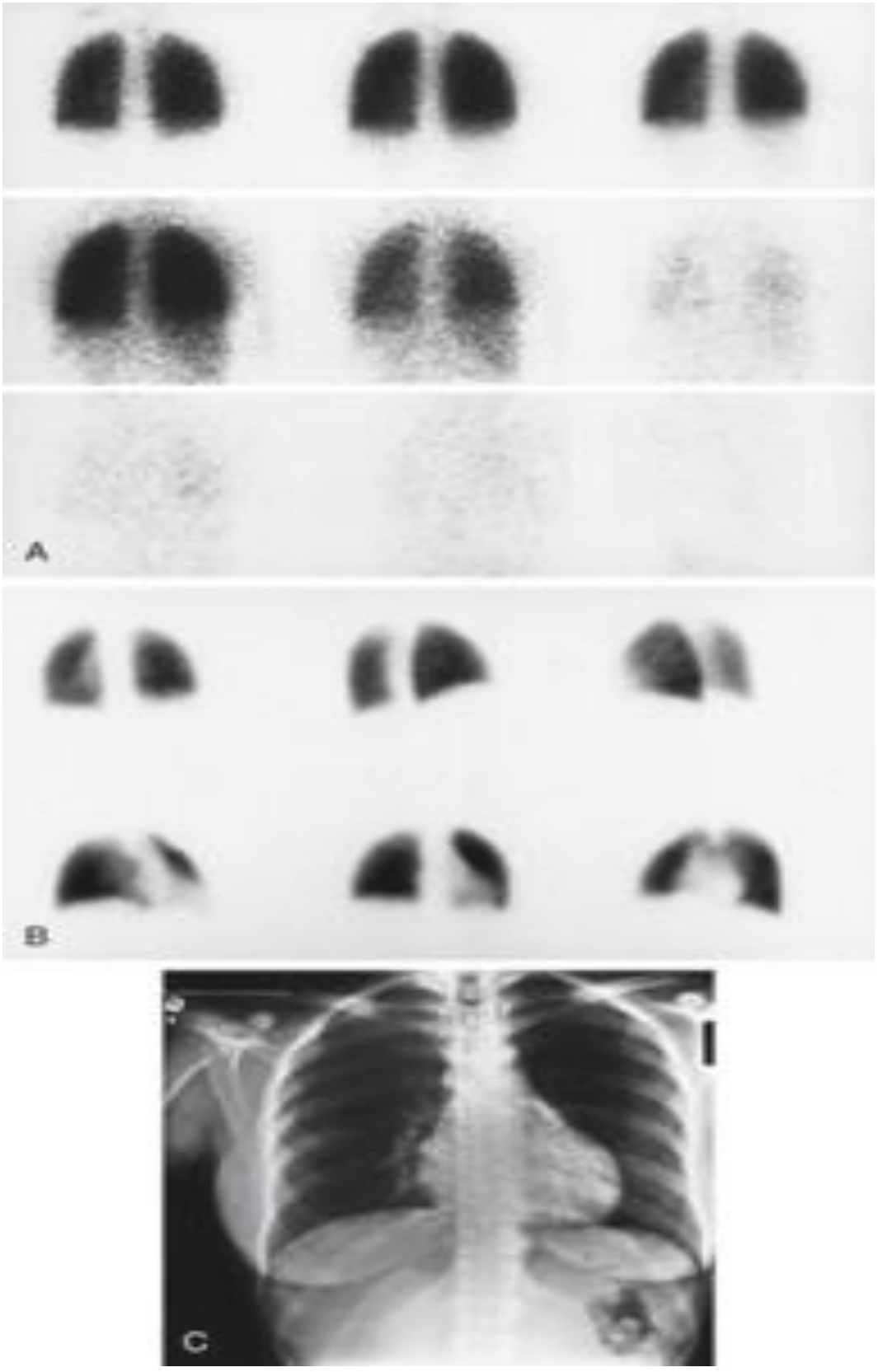


Figure 2: A, Initial breath and equilibrium images are in the upper row. The sequential washout images in the middle and lower rows show no evidence of air trapping. B,

Corresponding Tc-99m MAA images show homogeneous distribution of tracer activity throughout the lungs. C, Chest radiograph was also normal.

Chapter 5: Pitfalls and Artefacts

- "Hot Spots": Occur due to injection of blood clots which inadvertently formed in the syringe (Figure 3).
- Swallowed Tc-99m DTPA: Intense uptake in the trachea and stomach may result from swallowed radiopharmaceutical (Figure 4).
- Liver uptake on ventilation images: Xenon is fat soluble (and somewhat soluble in blood) and it may be deposited in the liver- especially when there is fatty infiltration (Figure 5).
- Effusions: If the patient is scanned supine, effusions may collect posteriorly/superiorly and mimic a defect due to attenuation (Figure 6).
- Fissure sign: Tc-99m MAA perfusion images show a curvilinear defect in the area of the major fissure of the right lung due to effusion tracking along the fissure, negative for PE (Figure 7).
- Stripe sign: Perfusion on the right lateral view is seen anteriorly along the periphery of the lung, beyond an extensive area of decreased perfusion posterior to it strongly suggesting that the decreased perfusion in the upper lobe is ***not*** caused by PE (Figure 8).

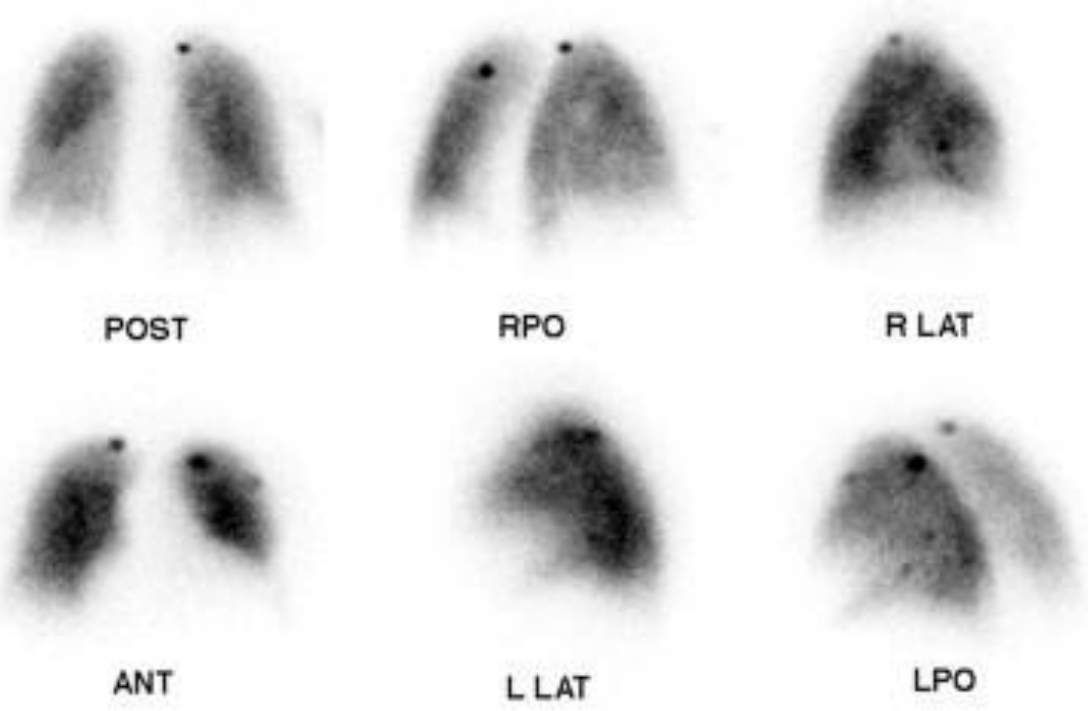


Figure 3: Injected blood clot artifact with Tc-99m MAA. Blood clots formed from drawing blood back into the syringe appear as focal hot spots when they are reinjected into the patient.

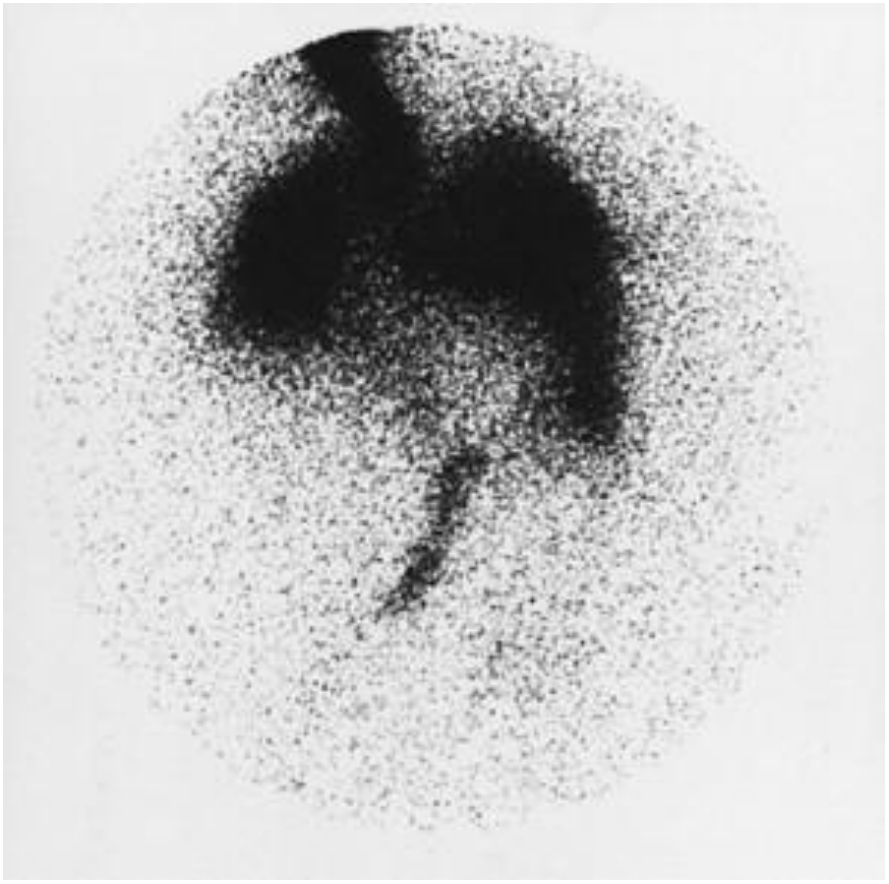


Figure 4: Swallowed Tc-99m DTPA in stomach

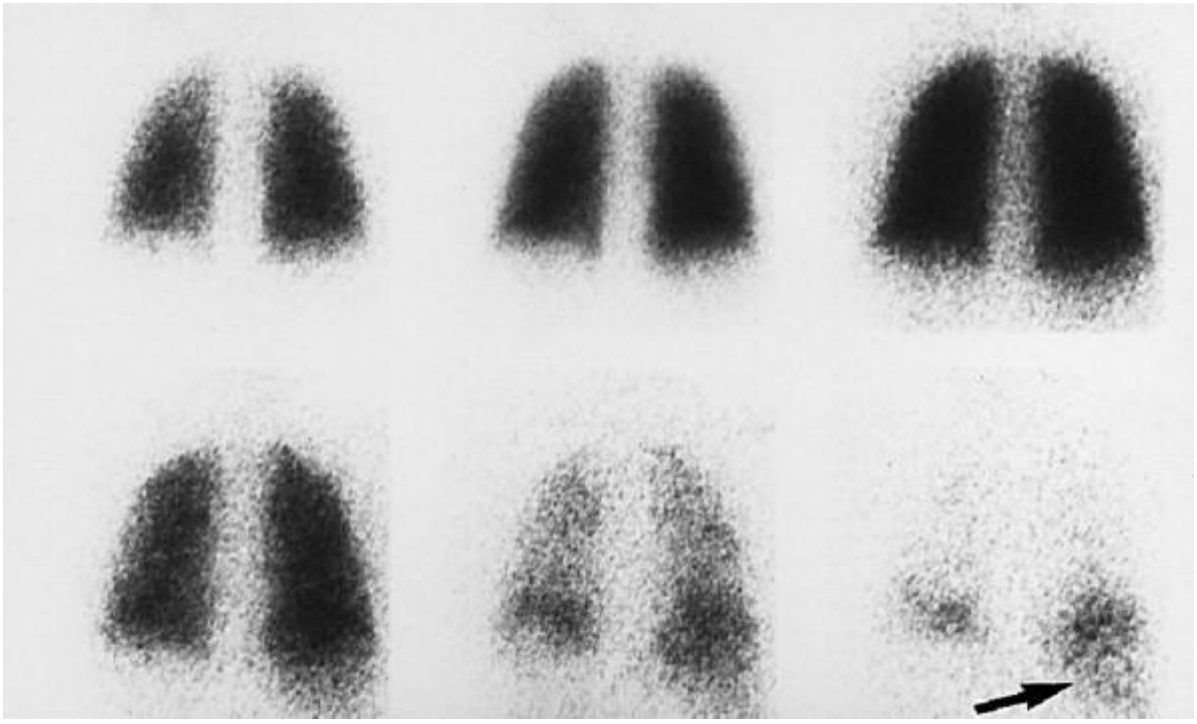


Figure 5: Xe-133 accumulation in the liver. Posterior ventilation images show delayed washout of xenon in the lung bases and significant xenon uptake in the region of the liver (arrow marked)

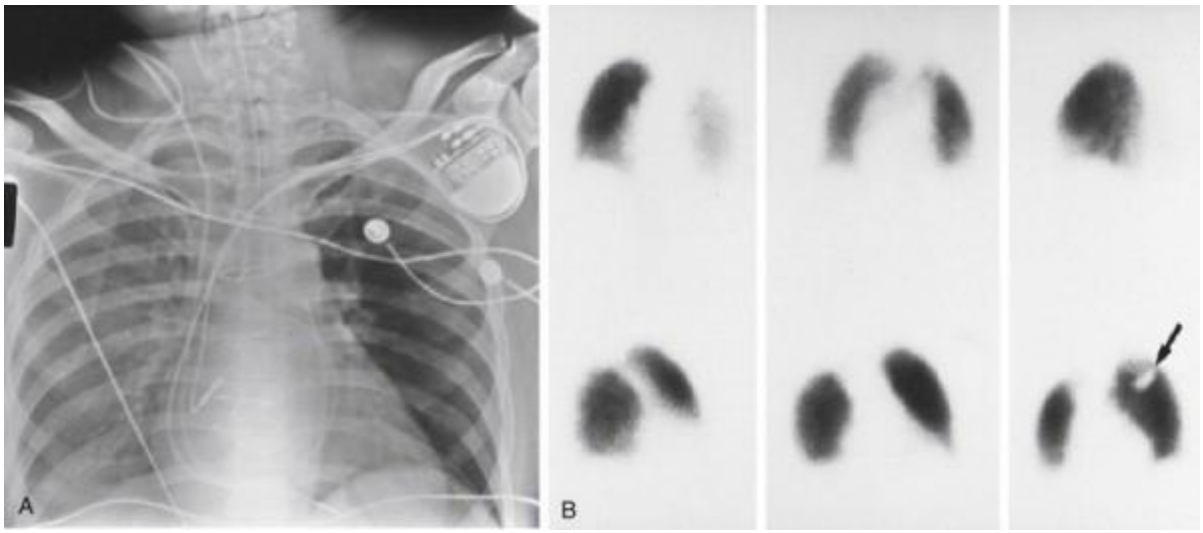


Figure 6: Pleural effusion effect. A, Anteroposterior chest radiograph reveals uniformly greater density in the right lung compared to the left caused by an effusion layering out posteriorly when the patient is supine. B, Corresponding Tc-99m MAA perfusion study shows decreased perfusion to the right lung on the posterior view (upper left-hand image), which is not seen on the other views, tipping off the observer to the explanation for the discrepancy. Blunting of the costophrenic angle is apparent. The pacemaker causes a well-defined defect (arrow).

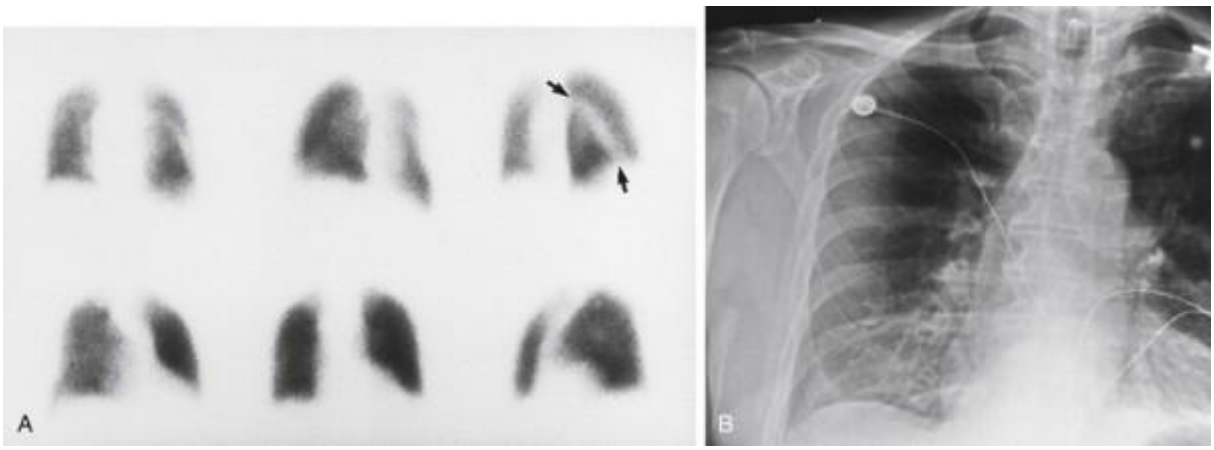


Figure 7: Fig 7. Fissure Sign. Tc-99m MAA perfusion images show a curvilinear defect in the area of the major fissure of the right lung (arrows) due to effusion tracking along the fissure, negative for PE.

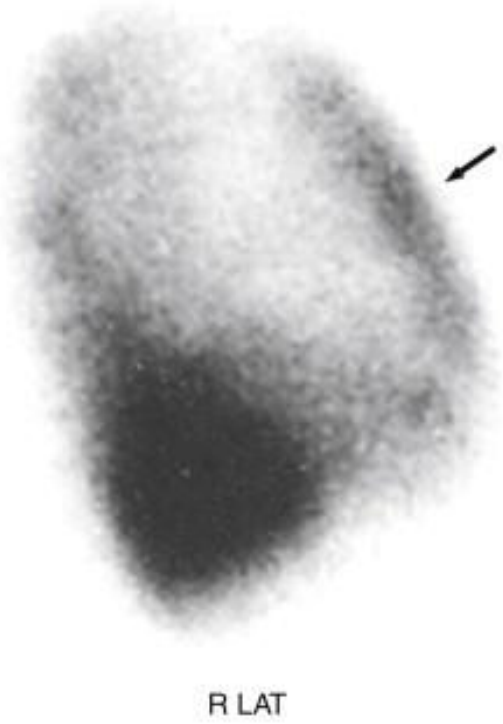


Figure 8: Stripe Sign. Perfusion on the right lateral view is seen anteriorly along the periphery of the lung (arrow), beyond an extensive area of decreased perfusion posterior to it strongly suggesting that the decreased perfusion in the upper lobe is ***not*** caused by PE.

Chapter 6: Differential Diagnosis

6.1 D/D for ventilation abnormalities

- Chronic airway abnormalities like destruction of bronchial walls in Chronic bronchitis, bronchiectasis
- Chronic airway abnormality – asthma, COPD
- Filling of Alveolar Spaces – Pneumonia, CCF
- Mucus plug impaction- large defects

6.2 D/D of Perfusion abnormalities

Primary Vascular Lesion

- Pulmonary thromboembolism
- Septic, fat, and air emboli (multiple moderate to large defects specially in lower lobes)
- Pulmonary artery hypoplasia or atresia
- Vasculitis

Primary Ventilation Abnormality

- Pneumonia
- Atelectasis
- Pulmonary edema
- Asthma
- Chronic obstructive pulmonary disease, emphysema, chronic bronchitis, bullae
- Mucous plug

Mass Effect

- Tumour
- Adenopathy
- Pleural effusion

Iatrogenic

- Surgery: Pneumonectomy lobectomy
- Radiation fibrosis (also post inflammatory fibrosis)

Chapter 7: History Essentials

- Reports must contain specific information to identify the patient, the specific procedure, indications for the examination, radiopharmaceutical used and activity administered, route of administration, interval between tracer administration and imaging.
- Allergy to Albumin should be enquired as in Perfusion imaging, tracer is labelled with Macro aggregated Albumin.

Assessment of Pre-test Probability for PE:

- Clinical and routine laboratory findings alone are not sufficient to diagnose PE.
- Clinical/lab findings help to determine pre-test probability, focus differential diagnosis and assess cardiopulmonary reserves.

Assessment of risk factors for DVT:

Virchow's Triad:

- Endothelial Injury: Trauma, surgery
- Stasis: Inactivity/ Immobility
- Hypercoagulability

Inherited:

- Protein C or S deficiencies
- Anti - phospholipid syndrome
- Factor V Leiden mutation
- Prothrombin gene mutation

Acquired:

- Pregnancy
- Malignancy
- Oral contraceptive pills
- Smoking

Modified WELL's criteria

1. Clinical symptoms of DVT: 3
2. Other diagnosis less likely than PE: 3 Heart rate >100 beats/min: 1.5
3. Immobilization or surgery <4 weeks: 1.5 Previous DVT or PE: 1.5
4. Hemoptysis: 1
5. Malignancy: 1

Clinical Probability Assessment

- High: >6 (41%)
- Moderate: 2-6 (16%)
- Low: <2 (0.5-2.7%)

ECG:

70% abnormal, Classic signs are new RBBB, T wave inversion in V1-V4. Most common abnormalities are non-specific ST-T wave changes

Chest x-ray

Atelectasis, infiltrates, and pleural effusions are common, but at similar rates in those with and without PE. 12% normal. Classic signs are

- Westermark's sign
- Hampton's hump

Bilateral lower extremity ultrasounds

Potentially useful if positive and non-diagnostic V/Q or negative CTPA, and no explanation for pulmonary symptoms other than PE. Many PE will be missed (only 30% of PE patients will have a positive ultrasound).

Laboratory abnormalities

- D-Dimers: Fibrin split product. Sensitivity of 80-85% but negative value does not exclude PE.
- Troponin: Elevated in 30-50 percent of moderate to large PE. Predictive of adverse prognosis but not useful for PE diagnosis
- BNP (brain natriuretic peptide): May help to rule out CHF as cause of dyspnea. May have prognostic value (BNP < 50 may be associated with a benign clinical course) but not useful for PE diagnosis.

Chapter 8: Imaging Technique Essentials

- Dose and number of particles need to be reduced in cases with Pulmonary Hypertension and Pregnancy. Number of particles reduced to 100,000 in pregnancy, 100,000-250,000 in Pulmonary HTN and 100,000-150,000 in cases with right to left shunt.
- Sequence of imaging. Whether ventilation or perfusion is performed first depends on the nature of radiotracer used and their half-lives. With Tc-99m labelled tracers, ventilation is usually performed first, followed by Perfusion scintigraphy.
- In cases with severe dyspnea, ventilation scintigraphy is compromised and activity gets trapped in central airways rendering the interpretation as inadequate. This needs to be mentioned in imaging protocol.
- Comparison made with recent CXR should be reported.

Chapter 9: Reporting Essentials

Terminology used during Reporting V/Q Scintigraphy

V/Q matched defect: Both scans abnormal in same area and of equal size

V/Q mismatch: Abnormal perfusion in an area of normal ventilation or a much larger perfusion defect than ventilation abnormality

Triple-match: V/Q matching defects in a region of chest radiographic abnormality, in which the radiographic abnormality is of the same size or smaller than the perfusion defect. It is unlikely to be from PE.

- Upper and mid lung zone triple match = Low probability
- Lower lung zone triple match = intermediate probability

Segmental defect: Characteristically wedge shaped and pleural based; conforms to segmental anatomy of the lung; may be caused by occlusion of pulmonary artery branches

- Large: >75% of a lung segment
- Moderate: 25%-75% of a lung segment
- Small: <25% of a lung segment

Non segmental defect: Does not conform to segmental anatomy or does not appear wedge shaped

PIOPED Criteria for Interpretation of PE:

(Prospective Investigation of Pulmonary Embolism Diagnosis trial)

- PIOPED I
- Modified PIOPED I
- PIOPED II
- Modified PIOPED II
- PIOPED III

In practice we use Modified PIOPED Criteria II.

How to diagnose PE on V/Q scan?

We could say on the basis of PIOPED (Prospective Investigation of Pulmonary Embolism Diagnosis) Criteria that there is

High Probability of PE (Risk of PE > 80%)

- Two or more large mismatched segmental defects (or the arithmetic equivalent of moderate or large defects) with normal radiograph
- Any perfusion defect substantially larger than radiographic abnormality

Non-Diagnostic (Low or Intermediate Probability for PE)

- All other findings not listed in High, Very low or Normal findings.
- Moderate Effusion (more than one third of a hemi-thorax

Low Probability of PE (Risk of PE < 20%)

- Non-segmental defects: tiny effusion blunting costophrenic angle, cardiomegaly elevated diaphragm, ectatic aorta
- Any perfusion defect with substantially larger radiographic abnormality
- ≥2 Matched ventilation and perfusion defects with normal chest radiograph
- Small subsegmental perfusion defects with normal radiograph
- Stripe sign

Normal

- No perfusion defects

Chapter 10: Expected Level of Competence

- Pre - test probability for PE should be calculated based on history, radiological investigations and laboratory values.
- Pregnancy, right to left heart shunt, pulmonary hypertension based on capillary wedge pressure values and Echo should be scrutinized as the number of particles need to be reduced in these cases.
- Dose need to be administered depending on the age of the patient.
- Report should include the number, size and location of segmental defects.
- Matched and mismatched defects should be calculated.
- Defects should be compared with corresponding areas of lung on recent CXR (acquired during last 24-48 hours).
- Look for pitfalls in images as described above to rule out false positive findings.
- In cases with severe dyspnea particularly when performing ventilation imaging using Tc-99m DTPA Aerosols, the interpretation should include the statement that the ventilation was compromised and not suitable for comparison with perfusion imaging. Rather perfusion scintigraphy should be compared with CXR in such case scenarios.
- Shunt quantification can be considered if there is uptake in brain parenchyma and kidneys on perfusion scan due to right to left heart shunting.
- Final interpretation should include the likelihood ratio / probability for PE based on Modified PIOPED criteria.

Chapter 11: Sample Reports

11.1 Case-1

Clinical information:

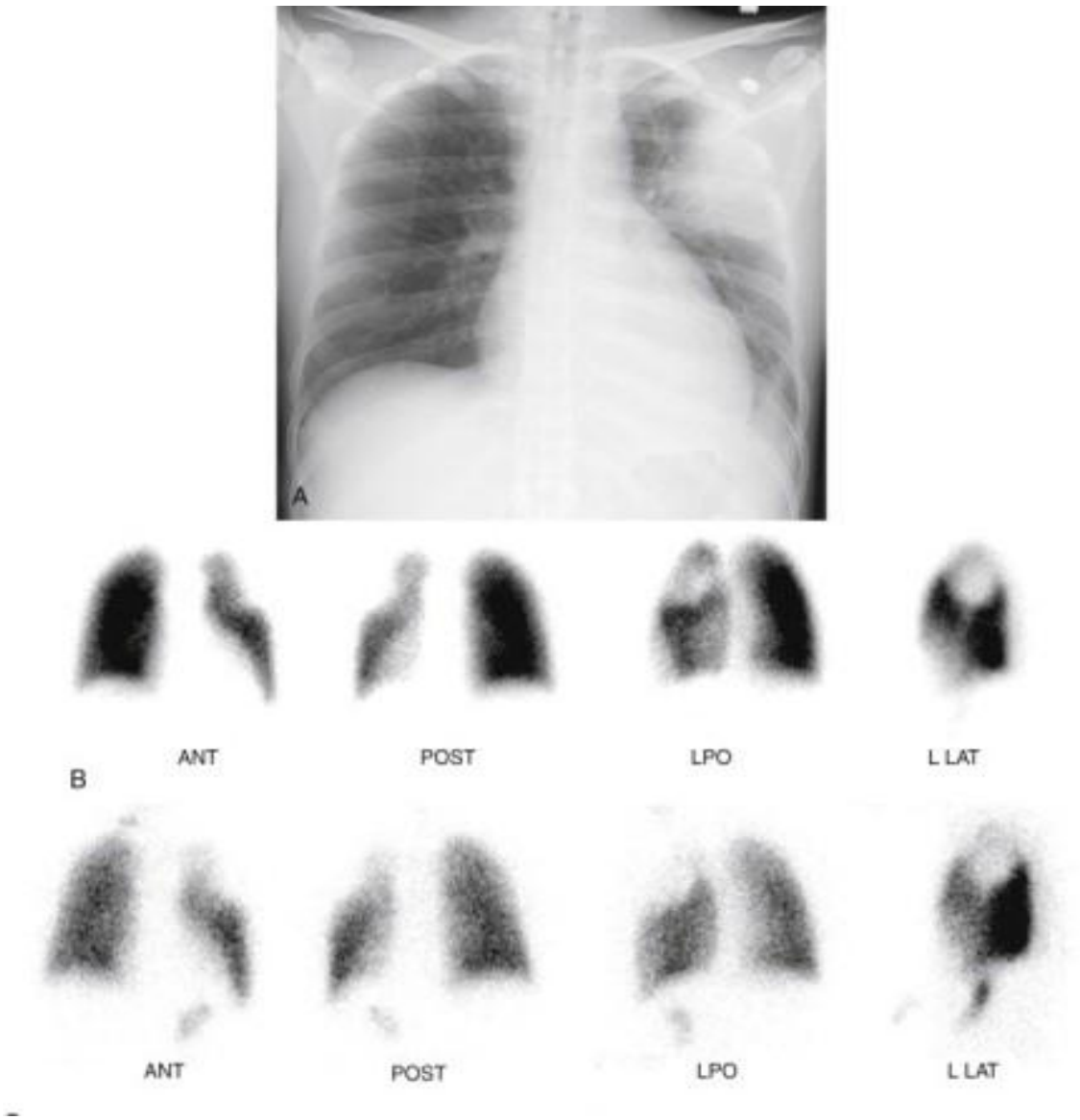
A 52 years old male presented in emergency with respiratory distress and hemoptysis. Patient has previous history of chronic Pulmonary embolism two years back and was treated with anticoagulant therapy. His HR = 120 bpm and EF = 58%. D- Dimers >200 IU/ml. Patient leads a sedentary lifestyle. Bilateral lower limb ultrasound is negative for DVT.

Pre-test Probability of PE: Intermediate

Comparison: None

Correlation: CXR performed on the same day as ventilation Perfusion imaging.

Technique: Following inhalation of 800 MBq of Tc-99m DTP, images of the chest were recorded in the anterior, posterior as well as left and right anterior and posterior oblique views. Perfusion scan was acquired after intravenous injection of 200 MBq of Tc-99m MAA using right hand cannula. Chest views were recorded in the anterior, posterior as well as left and right anterior and posterior oblique views.



Findings:

Perfusion Scan: Perfusion images show a large wedge-shaped perfusion defect in the left upper lobe and a mild overall decrease in tracer uptake on the left.

Ventilation: The ventilation images show complete matching of the abnormalities on the upper lobe of left lung.

Chest X-ray: Correlative anteroposterior radiograph shows a large pleural-based, left upper-lobe wedge-shaped opacity and a diffuse haze in left lung with blunting of left CP angle likely related to pleural effusion tracking along the chest wall. Findings are in keeping with triple matched defect in left upper lobe.

Impression:

Findings are suggestive of Low probability of pulmonary embolism.

11.2 Case-2

Clinical information:

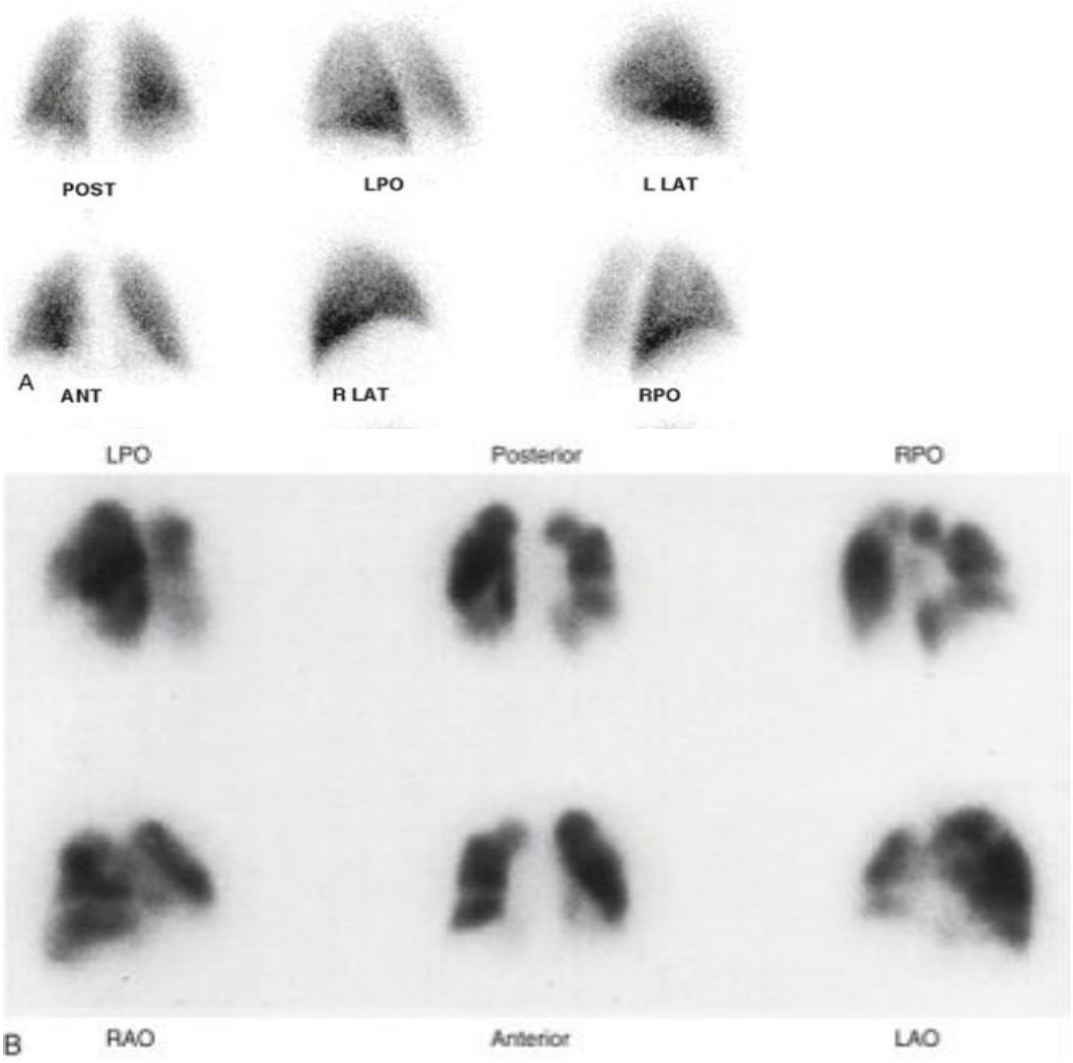
A 48 years old female with metastatic breast cancer and sudden onset of left pleuritic chest pain, for evaluation of possible pulmonary embolism. Patient is immobile due to pathological fracture of right femur. Baseline investigations reveal normal levels of D-Dimers and Echo shows EF = 55%, HR = 140 bpm. ECG shows RBBB and non-specific T-ST wave changes in chest leads. Lower limb ultrasound shows DVT in bilateral femoral vessels.

Pre-test Probability of PE: High

Comparison: None

Correlation: CXR performed a day before ventilation Perfusion

Technique: Following inhalation of 800 MBq of Tc-99m DTP, images of the chest were recorded in the anterior, posterior as well as left and right anterior and posterior oblique views. Perfusion scan was acquired after intravenous injection of 200 MBq of Tc-99m MAA using right hand cannula. Chest views were recorded in the anterior, posterior as well as left and right anterior and posterior oblique views.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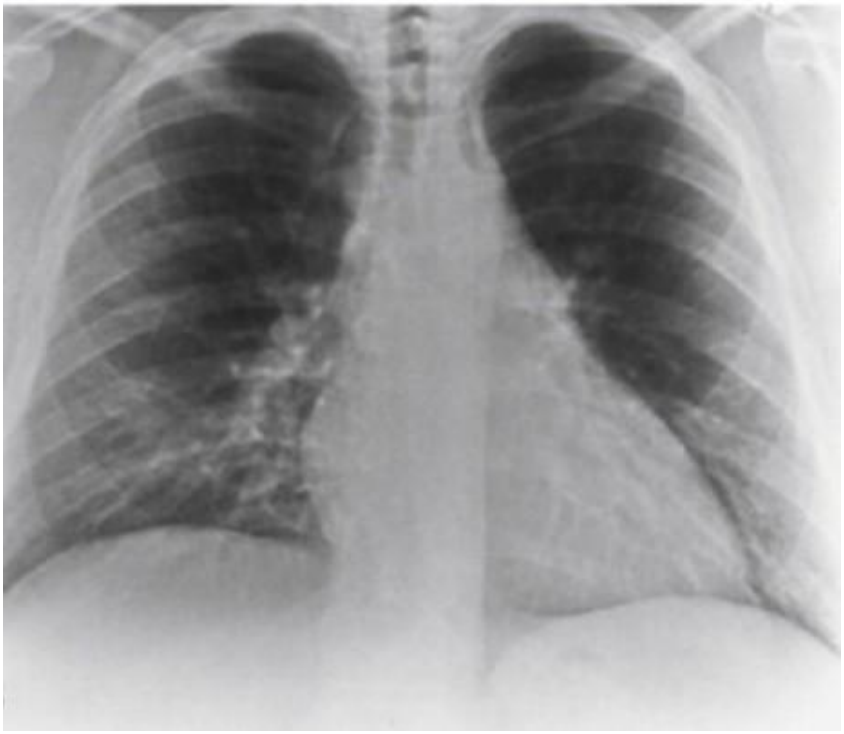

Findings:

Perfusion Scan: There are multiple wedge shaped pleural based moderate to large sized segmental areas of reduced perfusion involving the upper and lower lobes of bilateral lungs on the planar anterior, posterior and oblique images.

Ventilation: No focal area of abnormal reduced ventilation corresponding to the perfusion abnormality identified.

Chest X-ray: The anteroposterior chest film demonstrates well aerated lung in the areas of reduced perfusion.

Impression:

High probability of pulmonary embolism.

Chapter 12: Practical Algorithm for Diagnosing PE