



ORIGINAL RESEARCH ARTICLE

## Distribution of lung perfusion scintigraphy findings in pregnant women with suspected pulmonary embolism

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### ABSTRACT

**Introduction:** Pulmonary embolism (PE) is a potentially life-threatening condition and a leading cause of maternal mortality. Imaging plays a central role in the evaluation of suspected PE during pregnancy; however, concerns regarding radiation exposure and diagnostic yield remain. Lung perfusion scintigraphy is frequently used in this setting, yet data on the distribution of scan outcomes in pregnant patients are limited.

**Methods:** In this retrospective study, all pregnant women who underwent perfusion-only lung scintigraphy for suspected PE at a single tertiary center between May 2021 and January 2023 were included. Perfusion scans were performed using low-dose Tc-99m macroaggregated albumin (<sup>99m</sup>Tc-Tc-MAA) and interpreted independently by two nuclear medicine physicians according to PISAPED criteria. Scan results were classified as normal or high probability for PE.

**Results:** A total of 74 pregnant women were evaluated. The mean maternal age was approximately 30 years, and most patients were in the third trimester of pregnancy (75%). Normal perfusion scans were observed in 70 patients (94.5%), while 4 patients (5.5%) demonstrated high-probability findings for PE. No non-diagnostic scans were identified. All high-probability cases showed segmental or wedge-shaped perfusion defects consistent with PE.

**Conclusion:** Most pregnant women referred for lung perfusion scintigraphy for suspected PE had normal results, indicating a low prevalence of confirmed disease despite frequent clinical suspicion. Perfusion-only lung scintigraphy, when interpreted using PISAPED criteria, provides definitive results with a high normalcy rate in this population. These findings highlight the importance of optimizing clinical selection strategies to reduce unnecessary imaging and radiation exposure during pregnancy.

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## INTRODUCTION

Pulmonary embolism (PE) is one of the leading causes of death in pregnant women, accounting for approximately one death per 1,000 to 3,000 pregnancies [1]. Compared with the non-pregnant population, pregnancy increases the risk of PE by at least fourfold, making it the leading non-obstetric cause of maternal mortality [2]. Given the potentially fatal consequences of missed or delayed diagnosis for both the mother and the fetus, accurate and timely diagnosis of PE during pregnancy is critically important.

Several diagnostic imaging modalities are currently used for the evaluation of suspected PE in pregnant patients, including computed tomography pulmonary angiography (CTPA), lung scintigraphy, and magnetic resonance angiography (MRA) [3].

Among these, CTPA is considered the primary diagnostic tool for PE in non-pregnant patients because of its high diagnostic accuracy [4]. However, its use in pregnancy is limited by several drawbacks, including allergic reactions to iodinated contrast media, the risk of contrast-induced nephropathy, and radiation exposure to both the mother and the fetus [5]. Even with appropriate dose-reduction techniques, breast tissue may still receive a substantial radiation dose, which is associated with an increased lifetime risk of cancer [6].

MRA is a radiation-free imaging modality; however, its routine use in pregnancy is limited due to long acquisition time [7, 8] and concerns regarding gadolinium-based contrast safety [9, 10].

Lung scintigraphy represents another important diagnostic option for PE. This technique evaluates pulmonary perfusion and ventilation using radiopharmaceuticals, with images acquired by gamma cameras. Ventilation–perfusion single-photon emission computed tomography (V/Q SPECT) is based on the same principles but provides three-dimensional functional imaging [11, 12].

The results of V/Q SPECT scans, including lung perfusion scans, are commonly categorized as high probability (presence of PE), very low or normal probability (absence of PE), and inconclusive [13]. One of the major limitations of this modality is the relatively high percentage of non-diagnostic examinations, reported to be as high as 39%, which frequently necessitates additional imaging [14]. To reduce the rate of non-diagnostic results, it has been suggested that lung perfusion scans should only be performed in patients with abnormal chest radiographs [15].

Although pregnant women receive lower radiation doses to maternal breast tissue during lung scintigraphy compared with CTPA [16], fetal

radiation exposure during lung scintigraphy may be equal to or even greater than that of CTPA. Specifically, CTPA exposes the fetus to approximately 0.013 mSv, whereas perfusion scans expose the fetus to about 0.11–0.20 mSv [17, 18].

While low-dose radiation exposure may be justified to prevent a potentially life-threatening condition such as PE, radiation dose should always be minimized in accordance with the ALARA (As Low As Reasonably Achievable) principle [19].

Despite the widespread use of lung perfusion scintigraphy in pregnant women with suspected PE, there remains a need to better understand the distribution of scan outcomes in this population. Therefore, the present study aimed to determine the frequency of different lung perfusion scan outcomes in pregnant women suspected of PE, including normal and high-probability results. In addition, this study sought to evaluate the clinical implications of pulmonary perfusion scanning in this specific population and to estimate the number of pregnant women exposed to radiation as a result of positive scan findings during a defined time period.

## METHODS

### *Study design and population*

This retrospective study included all pregnant women who underwent perfusion-only lung scintigraphy for suspected pulmonary embolism at the Nuclear Medicine Department of Imam Reza Hospital, Kermanshah, Iran, between May 5, 2021, and January 7, 2023. Patients with incomplete medical records or unavailable imaging data were excluded.

Demographic variables recorded included maternal age and gestational age at the time of imaging.

### *Imaging protocol*

Lung perfusion scintigraphy was performed following intravenous administration of 2–3 mCi (74–111 MBq) of [<sup>99m</sup>Tc]Tc-MAA.

Planar images were acquired using a dual-head gamma camera equipped with a low-energy high-resolution collimator, centered at a 140 keV photopeak with a 20% energy window. Imaging was performed in eight standard projections (anterior, posterior, right and left lateral, right and left anterior oblique, and right and left posterior oblique), with a total of 400,000 counts acquired per projection.

Ventilation imaging was not performed in this cohort, in accordance with the institutional protocol aimed at minimizing radiation exposure during pregnancy.

### *Chest radiography*

Chest radiography (CXR) was performed prior to scintigraphy when clinically available. Available CXR images were reviewed to exclude alternative pulmonary pathologies that could account for

perfusion abnormalities and to ensure appropriate application of perfusion-only interpretation criteria.

#### *Image interpretation criteria*

All perfusion scans were independently interpreted by two board-certified nuclear medicine physicians using the Prospective Investigative Study of Acute Pulmonary Embolism Diagnosis (PISAPED) interpretation criteria. According to PISAPED, pulmonary embolism was diagnosed based on the presence of segmental or wedge-shaped perfusion defects, independent of ventilation imaging, provided that chest radiography was normal.

Scans were classified into two diagnostic categories only:

- Normal
- High probability for pulmonary embolism (PISAPED-positive)

No intermediate or non-diagnostic categories were used.

#### *Clinical data collection*

Clinical data were retrospectively extracted from electronic medical records and the Picture Archiving and Communication System (PACS), including presenting clinical symptoms and available laboratory data such as D-dimer results when performed.

In the absence of a systematic reference standard for all patients, formal diagnostic accuracy metrics were not assessed.

## **RESULTS**

A total of 74 pregnant women were referred for lung perfusion scintigraphy during the two-year study period, and complete medical and imaging records were available for all patients. The mean maternal age was approximately 30 years (range: 18–42 years). Based on gestational age, most patients were in the third trimester of pregnancy (75%), while the remaining 25% were in the second trimester.

Lung perfusion scintigraphy demonstrated normal perfusion patterns in 70 patients (94.5%), while 4 patients (5.5%) showed findings classified as high probability for pulmonary embolism. No non-diagnostic scans were observed.

Perfusion scintigraphy was performed using [<sup>99m</sup>Tc]Tc-MAA, with a mean injected activity of 2.4 mCi (range: 2–3 mCi). Among the four patients with high-probability perfusion scans, one patient was in the second trimester and three patients were in the third trimester of pregnancy.

Detailed review of patient records and scintigraphic images revealed the following perfusion abnormalities in the high-probability cases. In a 28-year-old pregnant woman, a large segmental wedge-

shaped perfusion defect was observed in the lateral segment of the right middle lobe. In two additional patients aged 28 and 32 years, decreased tracer uptake was identified in the lateral basal segment of the left lower lobe. In the fourth case, a 20-year-old pregnant woman demonstrated large segmental perfusion defects involving the superior segment of the left lower lobe and the superior lingular segment, with normal findings on chest radiography. The right lung showed homogeneous tracer uptake (Figure 1).

An example of a normal lung perfusion scan is presented in Figure 2, demonstrating homogeneous tracer distribution throughout both lungs without segmental perfusion defects.

## **DISCUSSION**

The present study demonstrated that the vast majority of lung perfusion scintigraphy examinations performed in pregnant women with clinical suspicion of pulmonary embolism were interpreted as normal, with only a small proportion showing high-probability findings for PE. This remarkably high normalcy rate is consistent with previous reports and underscores a well-recognized diagnostic challenge in the evaluation of suspected PE during pregnancy [20].

The low prevalence of high-probability perfusion scans observed in this study is comparable to findings reported by Abele et al. and Cutts et al., who also described a low diagnostic yield of imaging despite frequent clinical suspicion of PE in pregnant patients. Taken together, these data suggest that although PE is a serious and potentially life-threatening condition, its true incidence during pregnancy remains low, resulting in a substantial number of negative imaging studies in routine clinical practice [21, 22].

An important finding of the present study was the complete absence of non-diagnostic perfusion scans. This observation is most likely attributable to the use of perfusion-only imaging interpreted according to established PISAPED criteria, in conjunction with careful review of chest radiographs. Unlike traditional ventilation–perfusion mismatch–based interpretation, PISAPED relies on the identification of segmental or wedge-shaped perfusion defects and has been shown to substantially reduce the frequency of indeterminate results. Our findings support previous evidence indicating that, in appropriately selected pregnant patients with normal chest radiographs, perfusion-only scintigraphy can provide a high rate of definitive interpretations [23, 24].

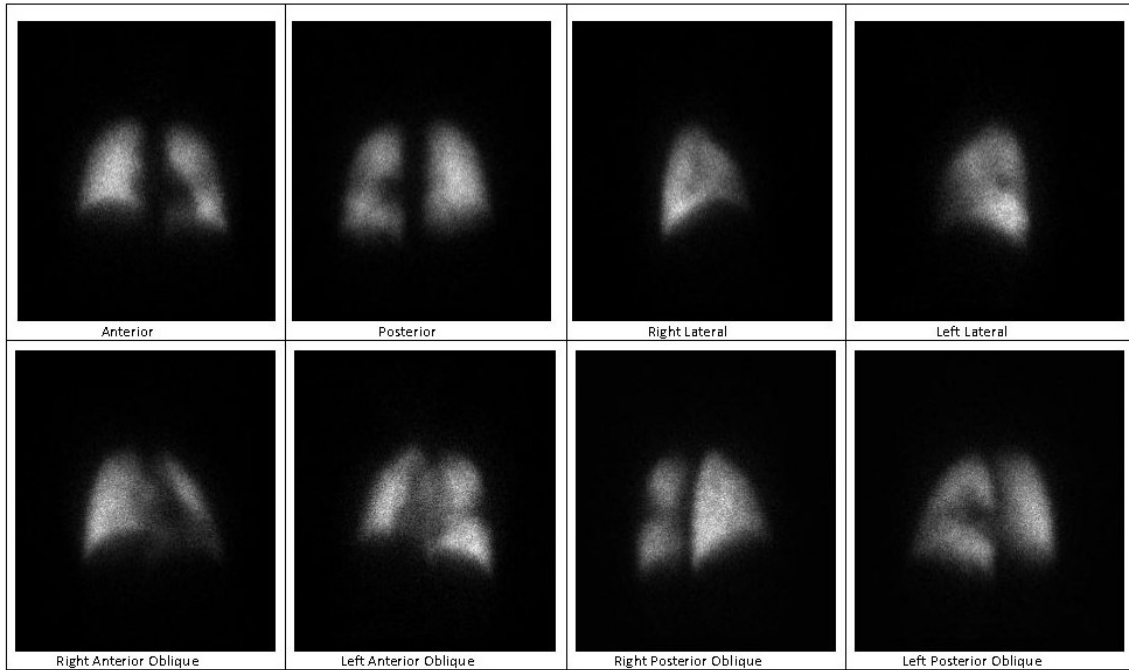


Figure 1. Abnormal perfusion lung scan with [<sup>99m</sup>Tc]Tc-MAA in a pregnant patient

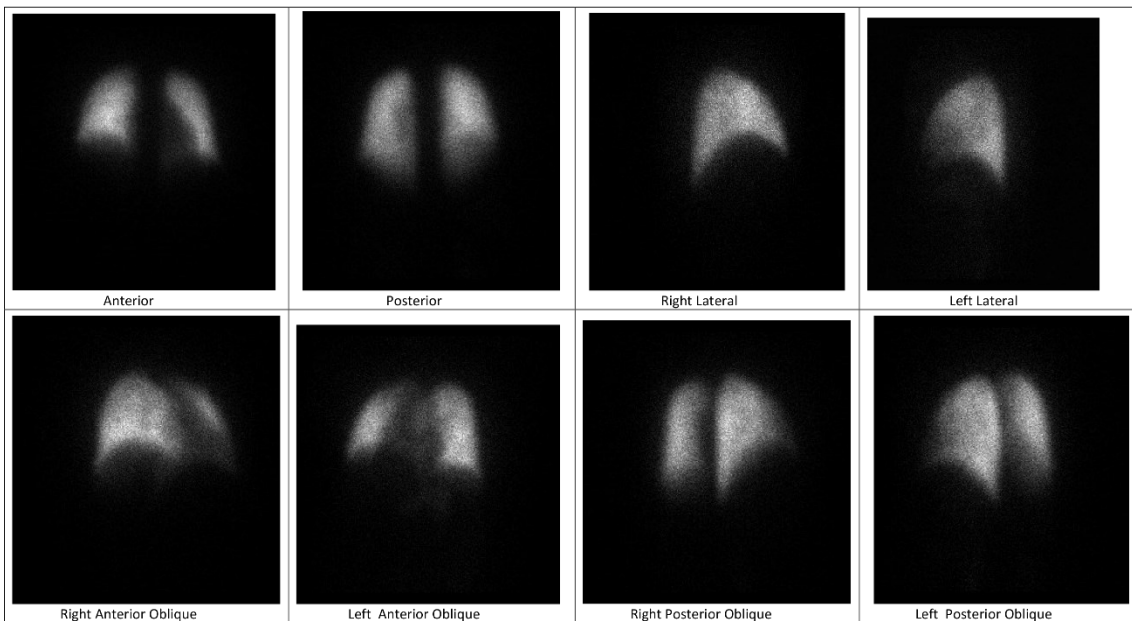


Figure 2. Normal perfusion lung scan with [<sup>99m</sup>Tc]Tc-MAA in a pregnant patient

Radiation exposure remains a central concern when imaging pregnant women. Perfusion scintigraphy is generally associated with lower radiation dose to maternal breast tissue compared with CT pulmonary angiography, while fetal exposure depends on administered activity and imaging protocol. In the present study, a low-dose [<sup>99m</sup>Tc]Tc-MAA protocol was used in accordance with established nuclear medicine safety recommendations. Nevertheless, the high proportion of normal examinations observed highlights the importance of optimizing

clinical referral pathways in order to minimize unnecessary radiation exposure to both the mother and the fetus [25, 26].

Emerging imaging modalities, such as ferumoxytol-enhanced magnetic resonance angiography, have been proposed as radiation-free alternatives for the evaluation of suspected PE in pregnancy. However, these techniques remain investigational, are not widely available, and lack large-scale validation. At present, lung perfusion scintigraphy continues to play an important role in the diagnostic workup of

suspected PE in pregnancy, particularly in centers where advanced MR-based techniques are not readily accessible [27, 28].

Several limitations of this study should be acknowledged. The retrospective design limited control over referral patterns and clinical decision-making. Ventilation imaging was not performed, which restricts direct comparison with full ventilation–perfusion protocols. In addition, this was a single-center study with a relatively small sample size, potentially limiting generalizability. Finally, a systematic gold-standard reference test was not available for all patients [29, 30].

Despite these limitations, this study provides valuable real-world insight into the diagnostic yield of lung perfusion scintigraphy in pregnant women and emphasizes the need for improved pregnancy-specific diagnostic strategies.

## CONCLUSION

This retrospective study demonstrated that the vast majority of pregnant women referred for lung perfusion scintigraphy because of suspected pulmonary embolism had normal scan findings, with only a small fraction showing high-probability results. These findings confirm that, although clinical suspicion of PE is common during pregnancy, the actual prevalence of confirmed disease is relatively low. Lung perfusion scintigraphy remains a safe and effective imaging modality for the evaluation of suspected PE in pregnancy. However, the exceptionally high normalcy rate observed in this study highlights the need for improved clinical selection and optimized diagnostic pathways to reduce unnecessary imaging and radiation exposure. Future prospective, multicenter studies incorporating pregnancy-adapted clinical assessment algorithms, standardized imaging protocols, and systematic reference standards are warranted to further refine diagnostic strategies for suspected pulmonary embolism in pregnant patients.

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