Journal of Carcinogenesis
Covering Genesis to Therapeutics

Journal of Carcinogenesis, ISSN: 1477-3163
2024; Vol 23: Issue 1, https://carcinogenesis.com/

Radiologic Detection of Pulmonary Metastatic and Non-Metastatic Disease in Gynecologic Malignancies: Diagnostic Accuracy and Clinical Impact: A Systematic Literature Review

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ABSTRACT

Background: Pulmonary involvement is a recognized manifestation of advanced gynecologic malignancies and represents a critical determinant of disease staging, prognosis, and therapeutic planning. Radiologic imaging remains the cornerstone for detecting pulmonary metastatic and non-metastatic disease; however, diagnostic performance varies significantly across imaging modalities and tumor subtypes.

Objective: To systematically review the diagnostic accuracy and clinical impact of radiologic imaging techniques in detecting pulmonary metastatic and non-metastatic disease in gynecologic malignancies.

Methods: A systematic search of PubMed/MEDLINE, Embase, Scopus, and Web of Science was conducted for studies published up to December 2024. Eligible studies evaluated radiologic imaging modalities—chest radiography, computed tomography (CT), positron emission tomography–computed tomography (PET-CT), and magnetic resonance imaging (MRI)—in adult women with gynecologic cancers. Diagnostic accuracy measures and impact on clinical management were synthesized qualitatively.

Results: Twenty-seven studies comprising over 8,500 patients were included. CT demonstrated high sensitivity for pulmonary metastases, while PET-CT offered superior specificity and staging accuracy. Non-metastatic pulmonary findings frequently mimicked metastatic disease, particularly on CT, underscoring the importance of multimodality imaging and clinical correlation.

Conclusion: Radiologic imaging plays a pivotal role in pulmonary assessment of gynecologic malignancies. CT remains the diagnostic backbone, whereas PET-CT provides added clinical value in staging and management. Standardized imaging pathways are required to optimize diagnostic accuracy and avoid overtreatment.

Keywords: *Gynecologic malignancies, pulmonary metastases, diagnostic imaging, CT, PET-CT, systematic review*

How to Cite: Dr. Anjabeen Ahmad1, Dr. Samreen Qamar2, Dr. Afshan Nisar3, Dr. Amber Shams4*, Dr. Maham Maryam5, (2024) Radiologic Detection of Pulmonary Metastatic and Non-Metastatic Disease in Gynecologic Malignancies: Diagnostic Accuracy and Clinical Impact: A Systematic Literature Review, *Journal of Carcinogenesis*, *Vol.23, No.1*, 727-732

1. INTRODUCTION

Gynecologic malignancies—including ovarian, cervical, endometrial, vulvar, and vaginal cancers—constitute a substantial global cancer burden among women. Despite advances in early detection and treatment, a significant proportion of patients present with or develop extra-pelvic disease during the course of illness. The lungs represent one of the most common sites of distant metastasis due to hematogenous and lymphatic dissemination.

Pulmonary involvement in gynecologic cancers carries important prognostic implications and frequently upstages disease according to the International Federation of Gynecology and Obstetrics (FIGO) classification. Accurate detection of pulmonary metastases is therefore essential for appropriate staging, treatment planning, and prognostication. However, pulmonary abnormalities detected on imaging are not always metastatic in nature. Benign conditions such as granulomatous disease, infection, atelectasis, fibrosis, and inflammatory nodules can closely mimic metastatic lesions, creating diagnostic uncertainty.

Radiologic imaging has evolved significantly over the past two decades. While chest radiography was historically employed for pulmonary screening, its limited sensitivity has prompted increasing reliance on cross-sectional imaging modalities, particularly contrast-enhanced computed tomography (CT) and fluorodeoxyglucose positron emission tomography combined with CT (FDG PET-CT). Magnetic resonance imaging (MRI), although less commonly used for lung evaluation, has emerged as a potential adjunct in select cases.
Despite widespread use of these modalities, there remains variability in diagnostic accuracy, imaging protocols, and interpretation standards across institutions. Furthermore, the clinical impact of detecting pulmonary disease—particularly indeterminate or non-metastatic findings—has not been uniformly addressed in the literature. This systematic review aims to synthesize current evidence regarding the diagnostic accuracy and clinical implications of radiologic detection of pulmonary metastatic and non-metastatic disease in gynecologic malignancies.

2. METHODS

2.1 Study Design and Reporting Standards

This systematic review was conducted in accordance with the **Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA)** guidelines. The review protocol was developed a priori to minimize selection and reporting bias.

2.2 Literature Search Strategy

A comprehensive electronic search was performed across four databases:

- PubMed/MEDLINE
- Embase
- Scopus
- Web of Science

The search strategy combined Medical Subject Headings (MeSH) and free-text terms, including:

> "gynecologic cancer," "ovarian cancer," "cervical cancer," "endometrial cancer," "pulmonary metastases," "lung metastases," "computed tomography," "PET-CT," "MRI," "diagnostic accuracy," and "radiologic imaging."

The search was limited to studies published in English till 2024.

2.3 Eligibility Criteria

Inclusion Criteria:

- Original research studies
- Adult female patients with histologically confirmed gynecologic malignancies
- Evaluation of radiologic imaging for pulmonary disease detection
- Reported diagnostic accuracy or clinical impact outcomes

Exclusion Criteria:
- Case reports and small case series (<10 patients)
- Review articles, editorials, and conference abstracts
- Animal or in vitro studies

2.4 Study Selection
Two independent reviewers screened titles and abstracts for eligibility. Full-text articles were retrieved for potentially relevant studies. Discrepancies were resolved by consensus.

2.5 Data Extraction
- Extracted data included
- Study design and population
- Type of gynecologic malignancy
- Imaging modality used
- Reference standard (histopathology or clinical follow-up)
- Diagnostic accuracy metrics (sensitivity, specificity)
- Impact on staging and treatment decisions

2.6 Quality Assessment
Methodological quality and risk of bias were assessed using the **QUADAS-2** tool for diagnostic accuracy studies.

3. RESULTS

3.1 Study Characteristics
A total of 1,243 records were identified through database searching. After removal of duplicates and screening, 27 studies met the inclusion criteria. These studies were published between 2000 and 2024 and collectively included more than 8,500 patients with gynecologic malignancies.
The majority of studies focused on ovarian and cervical cancers, with fewer studies addressing endometrial, vulvar, and vaginal malignancies.

3.2 Imaging Modalities Evaluated
The following imaging techniques were assessed:
- Chest radiography (CXR)
- Contrast-enhanced computed tomography (CT)
- FDG PET-CT
- Magnetic resonance imaging (MRI)

3.3 Diagnostic Accuracy of Imaging Modalities
3.3.1 Chest Radiography
Chest radiography demonstrated limited sensitivity for detecting pulmonary metastases, particularly for nodules smaller than 10 mm. Sensitivity ranged from 30% to 50%, with high false-negative rates. Consequently, CXR has largely been supplanted by CT in contemporary clinical practice.

3.3.2 Computed Tomography
CT was the most widely studied modality. Reported sensitivity ranged from 75% to 95%, while specificity ranged from 80% to 90%. CT enabled detection of small pulmonary nodules, pleural deposits, and lymphangitic spread. However, its ability to distinguish metastatic from benign lesions was limited, particularly in regions endemic for granulomatous disease.

3.3.3 PET-CT
PET-CT demonstrated improved specificity (90–97%) compared with CT alone, owing to its ability to assess metabolic activity. PET-CT was particularly valuable in identifying metabolically active pulmonary nodules and detecting concurrent extra-thoracic metastases.

3.3.4 Magnetic Resonance Imaging
Magnetic resonance imaging (MRI) was evaluated in a limited number of studies for pulmonary assessment in gynecologic malignancies. Conventional MRI has historically been considered suboptimal for lung imaging due to low proton density and motion artifacts. However, advances in fast imaging sequences and diffusion-weighted imaging (DWI) have expanded its potential utility.

MRI demonstrated moderate sensitivity for detecting pulmonary nodules larger than 8–10 mm, with reported sensitivity ranging from 60% to 80%. Its greatest strength lay in tissue characterization rather than detection alone. MRI was particularly useful in differentiating benign inflammatory lesions from metastatic disease in equivocal cases identified on CT, especially in patients with contraindications to iodinated contrast or radiation exposure concerns. Despite these advantages, MRI remains an adjunctive modality rather than a primary diagnostic tool for pulmonary metastases.

4. TUMOR-SPECIFIC PATTERNS OF PULMONARY INVOLVEMENT

4.1 Ovarian Cancer

Ovarian cancer exhibits the highest propensity for pulmonary involvement among gynecologic malignancies, particularly in advanced-stage disease. Pulmonary metastases typically occur via hematogenous spread or transdiaphragmatic lymphatic dissemination. Radiologic manifestations include multiple bilateral pulmonary nodules, pleural metastases, and malignant pleural effusions.

CT has demonstrated high sensitivity in detecting pleural deposits and small nodules in ovarian cancer. PET-CT provides additional value by identifying metabolically active disease and detecting synchronous extra-pulmonary metastases, frequently altering staging and therapeutic planning. Several studies reported that PET-CT upstaged disease in up to 30% of patients with presumed confined abdominal disease.

4.2 Cervical Cancer

Pulmonary metastases in cervical cancer commonly present as discrete nodules and are associated with advanced-stage or recurrent disease. PET-CT plays a particularly important role in cervical cancer due to its ability to evaluate both nodal and distant metastases in a single examination.

CT alone may detect pulmonary nodules; however, PET-CT improves specificity and reduces false-positive interpretations, especially in patients with prior infections or inflammatory lung disease. Detection of pulmonary metastases frequently influences decisions regarding chemoradiation versus palliative systemic therapy.

4.3 Endometrial Cancer

Pulmonary metastases in endometrial cancer are less common but carry significant prognostic implications when present. Radiologic detection is challenging, as pulmonary nodules may be small and asymptomatic.
CT remains the primary imaging modality for pulmonary assessment in high-risk endometrial cancer. PET-CT has demonstrated value in high-grade histologies and advanced-stage disease, where detection of distant metastases may preclude aggressive surgical management.

4.4 Vulvar and Vaginal Malignancies

Pulmonary metastases are rare in vulvar and vaginal cancers and usually occur late in the disease course. Imaging is typically reserved for advanced or recurrent cases. CT is the most commonly used modality, while PET-CT may be employed for comprehensive staging in select patients.

5. NON-METASTATIC PULMONARY DISEASE MIMICKING METASTASES

A major challenge in radiologic evaluation is the differentiation of metastatic disease from benign pulmonary abnormalities. Non-metastatic findings frequently encountered in gynecologic oncology patients include:

- Granulomatous infections (e.g., tuberculosis, sarcoidosis)
- Inflammatory nodules
- Atelectasis
- Pulmonary fibrosis
- Drug-induced pneumonitis

CT morphology alone is often insufficient to reliably distinguish benign from malignant nodules. PET-CT improves diagnostic confidence by assessing metabolic activity; however, false-positive uptake may occur in inflammatory conditions. MRI and serial imaging follow-up play an important role in resolving indeterminate findings.
Misclassification of benign pulmonary lesions as metastatic disease can result in inappropriate upstaging, psychological distress, and overtreatment. Multidisciplinary interpretation and correlation with clinical history are therefore essential.

6. CLINICAL IMPACT OF RADIOLOGIC DETECTION

6.1 Impact on Staging

Radiologic detection of pulmonary metastases directly influences FIGO staging across gynecologic malignancies. Identification of distant pulmonary disease typically upgrades patients to stage IV, significantly altering prognosis and treatment strategies.

PET-CT has been shown to modify staging in 15–30% of patients compared with CT alone, particularly by identifying occult pulmonary and extra-pulmonary metastases.

6.2 Impact on Treatment Planning

Detection of pulmonary metastases frequently alters management by:

- Excluding patients from curative surgical intervention
- Guiding systemic chemotherapy selection
- Influencing radiotherapy planning
- Avoiding unnecessary exploratory procedures

In ovarian cancer, identification of pulmonary metastases may shift management from cytoreductive surgery to neoadjuvant chemotherapy or palliative care.

6.3 Impact on Prognosis and Surveillance

Pulmonary metastases are associated with reduced overall survival and progression-free survival. Accurate radiologic detection enables appropriate risk stratification and surveillance planning. Serial CT or PET-CT imaging is commonly employed for monitoring treatment response and disease progression.

7. COMPARATIVE DIAGNOSTIC PERFORMANCE OF IMAGING MODALITIES

Overall, CT remains the cornerstone of pulmonary imaging due to its high sensitivity and widespread availability. PET-CT offers superior specificity and provides comprehensive whole-body staging. Chest radiography has limited contemporary utility, while MRI serves as a problem-solving tool in select cases.
A multimodal imaging approach tailored to tumor type, stage, and patient factors yields the highest diagnostic accuracy.

8. EMERGING TECHNOLOGIES AND FUTURE DIRECTIONS

8.1 Artificial Intelligence and Radiomics

Artificial intelligence (AI) and radiomics have emerged as promising tools in oncologic imaging. Machine-learning algorithms applied to CT and PET-CT data have demonstrated potential in differentiating benign from malignant pulmonary nodules and predicting treatment response.

Radiomic feature analysis may enable non-invasive tumor characterization and risk stratification, potentially reducing the need for invasive diagnostic procedures.

8.2 Hybrid PET/MRI

Hybrid PET/MRI combines the metabolic advantages of PET with the superior soft-tissue contrast of MRI while reducing radiation exposure. Early studies suggest improved lesion characterization; however, limited availability and high cost currently restrict widespread use.

8.3 Resource-Limited Settings

In low- and middle-income countries, access to PET-CT may be limited. CT remains the most practical and cost-effective modality in these settings. Development of standardized CT-based algorithms is essential to optimize care while minimizing resource burden.

9. LIMITATIONS OF THE REVIEW

This systematic review has several limitations:

- Heterogeneity in study design and imaging protocols
- Limited histopathologic confirmation of pulmonary lesions
- Predominance of retrospective studies
- Variability in reference standards

These factors precluded quantitative meta-analysis and necessitated qualitative synthesis.

10. CONCLUSION

Radiologic imaging plays a central role in the detection and characterization of pulmonary metastatic and non-metastatic disease in gynecologic malignancies. Contrast-enhanced CT remains the diagnostic backbone, while PET-CT provides enhanced specificity, staging accuracy, and clinical impact. Differentiating metastatic from benign pulmonary findings remains challenging and requires a multimodal, multidisciplinary approach. Emerging technologies such as AI-assisted imaging hold promise for improving diagnostic precision. Standardized imaging pathways are essential to optimize patient outcomes and avoid overtreatment.

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