ISSN (Online): 2455-3662
EPRA International Journal of Multidisciplinary Research (IJMR) - Peer Reviewed Journal
Volume: 12| Issue: 9| September 2026|| Journal DOI: 10.36713/epra2013 || SJIF Impact Factor 2026: 8.753 || ISI Value: 1.188

IMAGING BIOMARKERS OF PULMONARY INFECTIONS: INTEGRATING RADIOLOGICAL PATTERNS WITH MICROBIOLOGICAL DIAGNOSIS

A NARRATIVE STATE-OF-THE-ART REVIEW

Pramod Kumar V[1]*; Abhishek Rathod[2]

[1]*Malla Reddy University, Hyderabad, Telangana, India*

[2]*Tutor, Department of Microbiology, KLE University, Belagavi, Karnataka, India*

ABSTRACT

Pulmonary infections remain diagnostically challenging because radiological appearances frequently overlap across bacterial, viral, mycobacterial and fungal diseases, while microbiological tests vary in sensitivity, turnaround time and specimen dependence. Imaging is therefore most useful when interpreted as a set of probabilistic biomarkers rather than as a stand-alone etiological test. Chest radiography provides rapid assessment of air-space disease and complications; computed tomography (CT) better characterizes distribution, airway involvement, cavitation, nodules and diffuse parenchymal abnormalities; and lung ultrasonography can provide a radiation-free bedside assessment in selected patients. Microbiological diagnosis has expanded from conventional culture toward nucleic-acid amplification tests, multiplex molecular assays and pathogen-specific antigen testing. This review synthesizes how imaging phenotypes can guide specimen selection and microbiological testing, with emphasis on community-acquired pneumonia, tuberculosis, invasive fungal disease and opportunistic infection. Particular attention is given to the limits of imaging specificity, colonization versus infection, false-negative microbiology, antimicrobial exposure and host-dependent imaging variation. An integrated radiology–microbiology workflow is proposed in which clinical context, imaging phenotype, specimen quality and laboratory results are interpreted together. Such integration may improve diagnostic precision, support targeted therapy and facilitate longitudinal monitoring, while avoiding overinterpretation of non-specific imaging findings.

KEYWORDS: *Pulmonary Infection; Chest Radiography; Computed Tomography; Lung Ultrasound; Microbiology; Molecular Diagnostics; Biomarkers; Tuberculosis; Aspergillosis; Pneumonia*

1. INTRODUCTION

Pulmonary infection encompasses a heterogeneous group of diseases caused by bacteria, viruses, fungi, mycobacteria and, less commonly, other organisms. The diagnostic problem is not simply to identify an abnormal lung, but to determine whether the abnormality represents infection, which pathogen or pathogen group is plausible, whether coinfection is present, and whether the process is active. Imaging and microbiology answer different parts of this problem. Imaging describes anatomy, distribution, burden and complications, whereas microbiology attempts to establish the biological agent or a microbiological correlate of infection.

Current pneumonia guidance defines diagnosis through a combination of clinical features and a new pulmonary infiltrate on chest imaging, while the intensity of microbiological testing depends on disease severity and clinical circumstances [1]. Imaging findings are often non-specific: lobar consolidation, multifocal opacities, ground-glass opacity and nodules may occur in multiple infectious and non-infectious conditions [2–4]. Conversely, microbiological results can be difficult to interpret because respiratory samples may reflect colonization, contamination or upper-airway carriage rather than lower-respiratory infection.

The concept of an imaging biomarker in this setting should therefore be understood broadly. A radiological biomarker is a reproducible imaging feature or quantitative characteristic that changes the probability of a diagnostic state, such as infection, a particular pathogen class, disease severity or treatment response. A microbiological biomarker includes organism detection, nucleic acid, antigen, culture or susceptibility information. The central premise of this review is that these biomarkers have greater clinical value when interpreted jointly than when treated as isolated binary tests.

2. REVIEW APPROACH

This narrative review was structured around four clinically relevant domains: (1) imaging phenotypes of pulmonary infection; (2) microbiological diagnostic modalities; (3) radiology–microbiology correlations for major pulmonary infectious syndromes; and (4) opportunities and limitations for integrated diagnostic pathways. Priority was given to peer-reviewed reviews, diagnostic studies, systematic reviews, meta-analyses and major professional or international guidance documents. Contemporary WHO tuberculosis diagnostic guidance and ATS/IDSA community-acquired pneumonia guidance were used as reference frameworks [1,5–8].

Because this is a narrative review rather than a systematic review, no pooled effect estimate is generated and no claim of exhaustive literature capture is made. The proposed framework is intended to support future prospective validation studies linking

ISSN (Online): 2455-3662
EPRA International Journal of Multidisciplinary Research (IJMR) - Peer Reviewed Journal
Volume: 12| Issue: 9| September 2026|| Journal DOI: 10.36713/epra2013 || SJIF Impact Factor 2026: 8.753 || ISI Value: 1.188

standardized imaging descriptors with specimen-level microbiological results.

3. REVIEW FINDINGS

The literature synthesized in this narrative review demonstrates that imaging biomarkers and microbiological biomarkers provide complementary, rather than interchangeable, information in pulmonary infection. Across the major infectious syndromes considered, radiological findings contributed most effectively to localization, characterization of disease distribution, estimation of disease burden, recognition of complications and formulation of a focused microbiological differential. Microbiological investigations, in contrast, provided the principal route toward etiological confirmation, resistance characterization and, in selected settings, pathogen-specific treatment decisions.

Three broad findings emerged from the review. First, no single imaging phenotype was sufficiently specific to establish the causative organism across the major pulmonary infections examined. Focal or lobar consolidation was compatible with bacterial pneumonia but could also occur with aspiration and mixed infection; tree-in-bud and centrilobular nodules increased consideration of mycobacterial or other endobronchial infection but were not pathognomonic; cavitation broadened the differential to tuberculosis, bacterial abscess, fungal disease and septic emboli; and diffuse ground-glass opacity occurred across infectious and non-infectious conditions. The practical implication is that imaging should modify diagnostic probability rather than be treated as a stand-alone etiological test.

Second, the diagnostic contribution of imaging varied according to modality. Chest radiography remained useful as an accessible first-line examination for detecting air-space disease, pleural effusion, cavitation and interval change, but its sensitivity was limited for subtle or early abnormalities. CT provided greater anatomical detail and was particularly useful for identifying airway-centered disease, nodules, cavitation, pleural involvement and diffuse parenchymal abnormalities. Lung ultrasonography provided a radiation-free bedside option for peripheral consolidation and pleural abnormalities and was especially relevant to triage and serial assessment. Quantitative CT and radiomics offered potentially reproducible numerical descriptors of lesion burden and texture, but the current evidence does not support their use as substitutes for microbiological confirmation because of scanner, protocol, segmentation and external-validation limitations.

Third, microbiological interpretation was strongly dependent on specimen quality, host context and the biological meaning of the detected target. Culture retained an important role because it can provide organism identification and antimicrobial susceptibility information, but yield may be reduced by prior antimicrobial exposure, inadequate specimens and organism-specific growth characteristics. NAATs and other molecular assays can shorten time to detection and are particularly important in tuberculosis, including detection of selected resistance markers. Multiplex respiratory PCR can accelerate identification of multiple targets, but detection of nucleic acid does not necessarily establish causation when colonization or carriage is possible. Similarly, fungal biomarkers such as galactomannan and β-D-glucan provide complementary evidence in appropriately selected patients but require interpretation alongside host factors, imaging and specimen type.

The syndrome-based synthesis further showed that the value of an imaging biomarker depends on the microbiological question it generates. In community-acquired pneumonia, imaging primarily establishes the presence and distribution of pulmonary disease and helps determine whether targeted microbiological testing is warranted according to severity and clinical context. In suspected tuberculosis, characteristic CT patterns can increase suspicion and help communicate the distribution and activity of disease, while rapid molecular testing remains necessary for microbiological confirmation and resistance assessment. In invasive fungal disease, CT findings such as nodules, halo-pattern abnormalities and cavitation are most informative when combined with host risk factors and fungal biomarkers. In Pneumocystis jirovecii pneumonia, diffuse ground-glass opacity provides an important imaging clue but has a broad differential, making targeted PCR and contextual interpretation necessary. In HAP and VAP, serial imaging is particularly valuable for temporal assessment, while microbiology is essential for distinguishing infection from common ICU mimics and for antimicrobial selection.

A further finding was the importance of temporal concordance. A coherent diagnosis is strengthened when the host context, imaging phenotype, microbiological result and subsequent clinical or radiological course point in the same direction. Conversely, discordance should prompt reassessment of the diagnosis, specimen adequacy, colonization versus infection and alternative non-infectious explanations. This is particularly relevant when a molecular assay detects an organism in a specimen from a patient whose imaging phenotype is non-specific.

Overall, the review supports a four-layer diagnostic model consisting of host context, imaging phenotype, microbiological evidence and temporal response. The evidence also identifies a major research gap: relatively few studies prospectively connect standardized radiological descriptors with specimen-level microbiological reference standards and clinically meaningful outcomes. Therefore, the current literature supports an integrated diagnostic framework, but not a universal imaging-to-pathogen rule or a validated radiological replacement for microbiological testing.

4. IMAGING AS A BIOMARKER IN PULMONARY INFECTION

4.1 Chest radiography

Chest radiography remains the most accessible first-line thoracic imaging test in many settings. Typical patterns include focal air-space consolidation, multifocal bronchopneumonia and diffuse or interstitial abnormalities [2,3]. Radiography is useful for identifying infiltrates, pleural effusion, cavitation and interval change, but sensitivity may be limited early in disease, in dehydration, in obesity, or when abnormalities are subtle or

ISSN (Online): 2455-3662
EPRA International Journal of Multidisciplinary Research (IJMR) - Peer Reviewed Journal
Volume: 12| Issue: 9| September 2026|| Journal DOI: 10.36713/epra2013 || SJIF Impact Factor 2026: 8.753 || ISI Value: 1.188

anatomically obscured. Importantly, radiographic appearance rarely establishes a specific pathogen.

In tuberculosis, chest radiography remains valuable for screening and triage, but abnormalities are not sufficiently specific to replace microbiological confirmation. WHO describes chest radiography as an important tool in TB detection, while modern diagnostic pathways increasingly pair imaging with rapid molecular testing [5,6].

4.2 Computed tomography

CT provides higher spatial resolution and can reveal abnormalities that are inconspicuous or absent on radiography. In selected patients with suspected pneumonia, CT may demonstrate parenchymal disease when the chest radiograph is negative or inconclusive [9,10]. CT also better depicts airway-centered disease, tree-in-bud nodules, cavitation, abscess formation, pleural disease, lymphadenopathy and diffuse ground-glass abnormalities.

CT should nevertheless be considered a probabilistic biomarker. A tree-in-bud pattern may suggest endobronchial spread, but it is not specific for tuberculosis; cavitation may occur in bacterial, mycobacterial and fungal disease; and ground-glass opacity has a broad differential diagnosis. Thus, CT is most useful when its pattern is translated into a targeted microbiological question rather than a definitive etiological label.

4.3 Lung ultrasonography

Lung ultrasonography offers bedside, radiation-free evaluation of peripheral lung abnormalities, including subpleural consolidation, dynamic air bronchograms, pleural-line abnormalities and pleural effusion. Recent evidence suggests that lung ultrasound can perform well for detecting community-acquired pneumonia when compared with CT-based reference standards, although performance varies with operator expertise, lesion location and patient population [11]. Its strongest interdisciplinary role may be rapid triage and serial assessment in emergency and critical-care settings, with microbiological testing providing etiological information.

4.4 Quantitative and advanced imaging biomarkers

Quantitative CT and radiomics can transform visual patterns into numerical descriptors such as lesion volume, texture, density distribution and spatial heterogeneity. These approaches may support severity assessment and phenotype discovery, but their clinical interpretation remains limited by scanner parameters, reconstruction algorithms, segmentation methods, population differences and lack of standardized external validation. A radiomic feature should therefore not be regarded as a microbiological surrogate until its association with pathogen-defined disease has been prospectively replicated.

5. MICROBIOLOGICAL BIOMARKERS

5.1 Conventional culture and microscopy

Culture remains important because it can provide organism identification and antimicrobial susceptibility information. However, culture is affected by prior antimicrobial therapy, specimen quality, organism growth characteristics and turnaround time. Respiratory microscopy may provide rapid clues, but its sensitivity and specificity depend strongly on specimen type and laboratory expertise.

5.2 Nucleic-acid amplification tests

NAATs can shorten the time to organism detection and are particularly important for tuberculosis. WHO's current TB diagnostic framework recommends rapid molecular testing as an initial diagnostic approach in appropriate symptomatic populations rather than relying solely on smear microscopy or culture [6–8]. These tests may also detect selected resistance markers, thereby linking microbiological identification to therapeutic decision-making.

5.3 Multiplex respiratory PCR

Multiplex molecular assays can simultaneously detect multiple viral and bacterial targets. Their clinical interpretation requires caution because detection of nucleic acid does not always establish causality, particularly for organisms capable of colonization. Recent reviews emphasize that multiplex bacterial PCR may provide faster information than conventional culture but requires quantitative and clinical interpretation to avoid unnecessary treatment [12].

5.4 Antigen and host-response biomarkers

Pathogen-specific antigen tests and host-response markers may complement imaging and direct microbiological evaluation. In invasive pulmonary aspergillosis, galactomannan and β-D-glucan are used in appropriate populations, although their performance depends on specimen type, host factors and pre-test probability [13–15]. Procalcitonin can contribute to assessment of bacterial infection but does not reliably distinguish bacterial from viral pneumonia on its own; a meta-analysis reported only moderate sensitivity and specificity [16].

6. RADIOLOGICAL–MICROBIOLOGICAL CORRELATION BY SYNDROME

6.1 Community-acquired pneumonia

CAP commonly presents as focal or multifocal air-space disease, although imaging patterns overlap substantially among bacterial and viral causes [2,3]. The ATS/IDSA guideline recommends selective rather than indiscriminate microbiological testing in adults with CAP, with broader testing in severe disease and selected epidemiological or treatment-related circumstances [1]. This distinction is important because a radiological biomarker should guide the question asked of the laboratory, not automatically trigger broad-spectrum molecular testing.

CT-only pneumonia illustrates the complementary value of modalities: a prospective multicenter study found a small subgroup in whom pneumonia was visible on CT but not on concurrent radiography, with pathogen profiles broadly similar to radiograph-positive pneumonia [9]. Thus, CT can increase lesion detection, but microbiological interpretation still depends on specimen quality and clinical context.

ISSN (Online): 2455-3662
EPRA International Journal of Multidisciplinary Research (IJMR) - Peer Reviewed Journal
Volume: 12| Issue: 9| September 2026|| Journal DOI: 10.36713/epra2013 || SJIF Impact Factor 2026: 8.753 || ISI Value: 1.188

6.2 Tuberculosis and nontuberculous mycobacterial disease

Pulmonary tuberculosis provides one of the clearest examples of interdisciplinary diagnosis. Upper-lobe cavitation, tree-in-bud nodules, centrilobular nodules, lymphadenopathy and miliary patterns may raise suspicion, but none is sufficiently specific to establish microbiological disease [17–21]. Studies evaluating CT activity have demonstrated an association between radiographic activity categories and microbiological yield, supporting the use of imaging to prioritize and interpret microbiological sampling rather than to replace it [21].

Current WHO guidance has expanded the role of rapid molecular tests and resistance detection, including low-complexity automated NAATs and newer molecular technologies [6–8]. The practical implication is that a radiologist identifying a suspicious pattern should communicate the possibility of active TB and its distribution so that the laboratory receives an appropriate respiratory specimen and the clinical team can select an appropriate rapid molecular pathway.

6.3 Invasive pulmonary aspergillosis and other fungal infections

Invasive pulmonary aspergillosis illustrates the importance of combining host factors, CT phenotype and fungal biomarkers. Nodules, consolidation, ground-glass halo and cavitation may be encountered, but no single CT sign is pathognomonic [13,22]. The EORTC/MSGERC imaging review identifies high-resolution CT as the preferred lung imaging modality in suspected invasive fungal disease and emphasizes that characteristic signs must be interpreted with host and microbiological evidence [22].

Serum and bronchoalveolar lavage galactomannan, β-D-glucan, fungal culture and PCR can contribute to diagnosis. A meta-analysis of serum galactomannan and β-D-glucan demonstrated that diagnostic performance varies between biomarkers and that combined testing may provide complementary information [14]. For chronic pulmonary aspergillosis, BAL galactomannan may outperform serum testing, but no single assay is sufficient for diagnosis [15].

6.4 Pneumocystis jirovecii pneumonia

PJP commonly manifests on CT as diffuse ground-glass opacity, sometimes with septal thickening, cysts or less typical patterns [23]. Because the radiological differential includes viral infection, pulmonary edema, diffuse alveolar haemorrhage and drug toxicity, CT should trigger targeted microbiological testing rather than be considered diagnostic. Respiratory-specimen PCR has high sensitivity but may detect colonization, particularly in some non-HIV populations; quantitative or contextual interpretation is therefore important [24].

6.5 Hospital-acquired and ventilator-associated pneumonia

In HAP and VAP, imaging abnormalities often overlap with atelectasis, pulmonary edema, ARDS and other ICU conditions. Serial radiography is useful for trend assessment and complication detection, while microbiology becomes essential for identifying resistant pathogens and guiding antimicrobial therapy. The interdisciplinary challenge is to determine whether a new or progressive opacity represents infection rather than another ICU process. Here, temporal imaging change, clinical deterioration, specimen quality and quantitative or molecular microbiology should be interpreted together.

7. IMAGING PATTERNS AS TRIGGERS FOR MICROBIOLOGICAL TESTING

A useful interdisciplinary strategy is to map imaging phenotypes to the most appropriate microbiological question. Focal consolidation can support routine bacterial evaluation in the appropriate clinical setting; tree-in-bud disease should prompt consideration of mycobacterial and other endobronchial infections; cavitation broadens the differential to TB, abscess, fungal disease and septic emboli; diffuse ground-glass disease in an immunocompromised host should trigger consideration of viral infection, PJP and fungal disease; and nodular or halo-pattern disease in a high-risk host may justify early fungal testing.

This approach reduces two common errors: over-testing based on non-specific imaging and under-testing when a radiological pattern indicates a high-risk infectious differential. The proposed framework is summarized in Figures 1–3 and Tables 1–3.

8. INTEGRATED IMAGING–MICROBIOLOGY BIOMARKER FRAMEWORK

The central concept is a four-layer evidence model: host context, imaging phenotype, microbiological evidence and temporal response. Host context modifies pre-test probability; imaging describes the anatomical phenotype; microbiology attempts etiological confirmation; and longitudinal assessment tests whether the combined interpretation remains coherent. A mismatch should trigger reassessment rather than automatic escalation of treatment.

For example, a patient with an upper-lobe cavitary lesion and positive TB NAAT has a coherent radiology–microbiology signal. In contrast, a patient with nonspecific bilateral ground-glass opacity and a positive upper-airway PCR for a potentially colonizing organism may require broader clinical evaluation before attributing the imaging to that organism. This distinction is especially important when multiplex assays are used.

9. LIMITATIONS AND DIAGNOSTIC PITFALLS

First, imaging specificity is limited. Most radiological patterns represent biological processes rather than individual organisms. Second, microbiological detection is specimen-dependent. Sputum may be inadequate, BAL may be invasive, and blood cultures may be negative despite localized pulmonary disease. Third, prior antimicrobial exposure can reduce culture yield. Fourth, molecular detection can identify nucleic acid without proving active tissue invasion. Fifth, host factors such as neutropenia, immunosuppression, HIV infection and structural lung disease can substantially alter imaging phenotypes.

Another limitation is interobserver variability in qualitative imaging interpretation. Standardized reporting templates, structured descriptors and quantitative imaging may

ISSN (Online): 2455-3662
EPRA International Journal of Multidisciplinary Research (IJMR) - Peer Reviewed Journal
Volume: 12| Issue: 9| September 2026|| Journal DOI: 10.36713/epra2013 || SJIF Impact Factor 2026: 8.753 || ISI Value: 1.188

improve reproducibility, but these tools require validation. Finally, the evidence base is heterogeneous: many studies evaluate imaging and microbiology separately, whereas relatively few prospectively link standardized radiological features to specimen-level microbiological outcomes.

10. FUTURE DIRECTIONS

Future interdisciplinary studies should prospectively pair standardized imaging descriptors with microbiological reference standards. Important endpoints include pathogen-specific diagnostic accuracy, time to microbiological diagnosis, antimicrobial modification, hospital length of stay, ICU outcomes and treatment response. Multimodal datasets combining CT, radiography, lung ultrasound, culture, NAAT, antigen assays and host-response biomarkers could enable clinically interpretable prediction models.

For tuberculosis, digital chest radiography and computer-aided detection are increasingly relevant to screening and triage, while rapid molecular diagnostics continue to expand [7,8]. For fungal infection, combined biomarker strategies and improved molecular assays may help address limitations of culture and single-marker testing [13–15]. In pneumonia, multiplex PCR may shorten the interval between presentation and pathogen detection, but prospective studies should determine when faster detection changes outcomes rather than merely increasing the number of detected organisms [12].

A key research priority is external validation across hospitals, imaging vendors, scanners, microbiology laboratories and patient populations. Without this, highly performing models may fail when transferred to other clinical environments.

11. CONCLUSION

The integrated evidence reviewed in this article indicates that radiological and microbiological biomarkers should be regarded as complementary components of pulmonary infection diagnosis rather than competing diagnostic strategies. Chest radiography, CT and lung ultrasonography provide information about the anatomical expression of disease, including location, distribution, extent, airway involvement, cavitation, pleural complications and temporal evolution. Culture, microscopy, nucleic-acid amplification tests, multiplex molecular assays, antigen testing and susceptibility methods provide information that imaging generally cannot establish reliably: the presence of a specific organism, microbiological activity and, where available, antimicrobial resistance. The strongest diagnostic interpretation therefore occurs when these evidence streams are evaluated together within the patient's host and epidemiological context.

An important conclusion is that imaging biomarkers are most clinically valuable when they formulate and prioritize the microbiological question. Focal or lobar consolidation may support investigation for common bacterial infection in an appropriate clinical setting, but it does not identify a specific bacterium. Tree-in-bud disease may raise suspicion for endobronchial spread and tuberculosis or other mycobacterial infection, but microbiological testing remains necessary. Cavitation should broaden the diagnostic pathway to include tuberculosis, bacterial abscess, fungal infection and septic embolic disease. Diffuse ground-glass abnormality in an immunocompromised patient can direct attention toward viral infection, Pneumocystis and fungal disease while also reminding clinicians that edema, hemorrhage and drug toxicity may produce similar appearances. Thus, imaging contributes most when it narrows or prioritizes the differential without prematurely converting a pattern into an etiological diagnosis.

The review also emphasizes that a positive microbiological result should not automatically be equated with active pulmonary infection. Specimen quality, prior antimicrobial exposure, colonization, contamination, upper-airway carriage and assay sensitivity can substantially influence interpretation. This is particularly important for multiplex molecular testing and respiratory PCR, in which detection of nucleic acid may have different clinical meanings depending on the organism and host. Conversely, a negative microbiological result does not necessarily exclude infection when the specimen is inadequate, the organism is difficult to recover, prior treatment has been administered, or the disease is localized. The diagnostic process should therefore remain specimen-aware and probability-based rather than being driven by isolated positive or negative results.

From a practical perspective, the proposed four-layer model—host context, imaging phenotype, microbiological evidence and temporal response—provides a structured way to reconcile concordant and discordant findings. A coherent signal, such as a compatible cavitary imaging phenotype together with a positive tuberculosis NAAT in an appropriate clinical context, strengthens the diagnostic interpretation. In contrast, nonspecific imaging combined with detection of a potentially colonizing organism should prompt reassessment rather than automatic attribution. Serial imaging adds another dimension by allowing the team to determine whether the anatomical trajectory is compatible with the microbiological and clinical course, while recognizing that radiological resolution may lag behind microbiological response.

The review further identifies an important distinction between current clinical utility and future biomarker development. Quantitative CT, radiomics, multimodal imaging and combined host-response or pathogen-specific biomarkers may eventually provide more standardized and reproducible phenotyping. However, such approaches require prospective validation, standardized acquisition and reporting protocols, external validation across scanners and institutions, and direct comparison with specimen-level microbiological reference standards. A radiomic feature or imaging signature should not be treated as a microbiological surrogate until its association with pathogen-defined disease and clinically meaningful outcomes has been independently replicated.

In conclusion, the available evidence supports an integrated radiology–microbiology workflow in which imaging helps define the phenotype and prioritize testing, microbiology provides etiological and resistance information, host factors establish pre-test probability, and longitudinal assessment tests the coherence of the overall diagnosis. Such an approach can improve diagnostic precision while reducing two opposing risks:

ISSN (Online): 2455-3662
EPRA International Journal of Multidisciplinary Research (IJMR) - Peer Reviewed Journal
Volume: 12| Issue: 9| September 2026|| Journal DOI: 10.36713/epra2013 || SJIF Impact Factor 2026: 8.753 || ISI Value: 1.188

excessive testing based on non-specific radiological findings and insufficient microbiological evaluation when imaging and host context indicate a high-risk infectious differential. Future prospective studies should focus on pathogen-specific diagnostic accuracy, time to microbiological diagnosis, antimicrobial modification, treatment response, hospital and ICU outcomes, and external validation. The principal message is therefore not that imaging can replace microbiology, but that the clinical value of both increases when their findings are interpreted together in a standardized, specimen-aware and longitudinal framework.

12. DECLARATIONS

Ethics approval

Not applicable. This is a narrative review of published literature and does not involve new human participants, identifiable patient data or experimental procedures.

Consent for publication

Not applicable.

Competing interests

The authors should update this statement according to the target journal's disclosure requirements before submission. Draft statement: The authors declare no competing interests.

Funding

No specific funding was received for preparation of this review, unless otherwise declared by the authors.

Author contributions

Pramod Kumar V: conceptualization, literature synthesis, radiology-focused analysis, manuscript drafting and final review. Abhishek Rathod: microbiology-focused analysis, literature synthesis, manuscript drafting and critical revision. Both authors approved the final manuscript.

Data availability

No new datasets were generated or analyzed for this narrative review.

Acknowledgements

None.

13. REFERENCES

1. *Metlay JP, Waterer GW, Long AC, et al. Diagnosis and Treatment of Adults with Community-acquired Pneumonia. An Official Clinical Practice Guideline of the American Thoracic Society and Infectious Diseases Society of America. Am J Respir Crit Care Med. 2019;200:e45-e67. doi:10.1164/rccm.201908-1581ST.*
2. *Franquet T. Imaging of pulmonary viral pneumonia. Radiology. 2011;260:18-39. doi:10.1148/radiol.11092149.*
3. *Webb WR. Radiology of community-acquired pneumonia. Radiol Clin North Am. 2005;43:497-512. doi:10.1016/j.rcl.2005.02.005.*
4. *Revel MP, Fournier LS, Hennebicque AS, et al. Imaging of community-acquired pneumonia: roles of imaging examinations, imaging diagnosis of specific pathogens and discrimination from noninfectious diseases. Eur J Radiol. 2014;83:1-12.*
5. *World Health Organization. Chest radiography in tuberculosis detection: summary of current WHO recommendations and guidance on programmatic approaches. Geneva: WHO; 2016.*
6. *World Health Organization. WHO consolidated guidelines on tuberculosis: module 3: diagnosis. Geneva: WHO; 2025.*
7. *World Health Organization. WHO consolidated guidelines on tuberculosis: module 3: diagnosis – rapid diagnostics for tuberculosis detection. 3rd ed. Geneva: WHO; 2024.*
8. *World Health Organization. WHO operational handbook on tuberculosis: module 3: diagnosis. Geneva: WHO; 2025.*
9. *Upchurch CP, Grijalva CG, Wunderink RG, et al. Community-Acquired Pneumonia Visualized on CT Scans but Not Chest Radiographs: Pathogens, Severity, and Clinical Outcomes. Chest. 2018;153:601-610. doi:10.1016/j.chest.2017.07.035.*
10. *Yoo H, et al. Chest computed tomography and chest X-ray in the diagnosis of community-acquired pneumonia: a retrospective observational study. BMC Pulm Med. 2021;21:250.*
11. *Llanos-Tejada F, et al. Pulmonary ultrasound versus chest radiography in the diagnosis of community-acquired pneumonia in adults: an updated systematic review and meta-analysis. Respir Med. 2025;225:101200. doi:10.1016/j.rmed.2025.101200.*
12. *Ling L, Lai CKC, Rhee C. Bacterial multiplex polymerase chain reaction tests for the diagnosis and management of pneumonia: ready for prime time? Thorax. 2025. doi:10.1136/thorax-2024-222297.*
13. *Alexander BD, Lamoth F, et al. Guidance on Imaging for Invasive Pulmonary Aspergillosis and Mucormycosis: From the Imaging Working Group for the Revision and Update of the Consensus Definitions of Fungal Disease from the EORTC/MSGERC. Clin Infect Dis. 2021;72(Suppl 2):S79-S88. doi:10.1093/cid/ciaa1855.*
14. *Huang QY, et al. Diagnostic performance of serum galactomannan and β-D-glucan for invasive aspergillosis in suspected patients: a meta-analysis. Medicine (Baltimore). 2024;103:e37300.*
15. *Denning DW, et al. Systematic review and meta-analysis of galactomannan antigen testing in serum and bronchoalveolar lavage for the diagnosis of chronic pulmonary aspergillosis: defining a cutoff. Mycoses. 2023;66:700-711. doi:10.1007/s10096-023-04639-0.*
16. *Kamat IS, et al. Procalcitonin to distinguish viral from bacterial pneumonia: a systematic review and meta-analysis. Clin Infect Dis. 2020;70:538-545.*
17. *Upadhyay S, et al. Procalcitonin correlates with but is not superior to other diagnostic markers of bacterial pneumonia. J Clin Microbiol. 2020;58:e01413-20.*
18. *Jeong YJ, Lee KS. Pulmonary tuberculosis: up-to-date imaging and management. AJR Am J Roentgenol. 2008;191:834-844. doi:10.2214/AJR.07.3896.*
19. *Bhalla AS, Goyal A, Guleria R, Gupta AK. Chest tuberculosis: radiological review and imaging recommendations. Indian J Radiol Imaging. 2015;25:213-225. doi:10.4103/0971-3026.161431.*
20. *Bhalla AS, MacDonald S, Murchison JT. Imaging in tuberculosis. Clin Radiol. 2015;70:111-120.*
21. *Lee SW, et al. Correlation of microbiological yield with radiographic activity on chest computed tomography in cases of*

ISSN (Online): 2455-3662
EPRA International Journal of Multidisciplinary Research (IJMR) - Peer Reviewed Journal
Volume: 12| Issue: 9| September 2026|| Journal DOI: 10.36713/epra2013 || SJIF Impact Factor 2026: 8.753 || ISI Value: 1.188

suspected pulmonary tuberculosis. Eur Radiol. 2019;29:2090-2098.

22. *García-Basteiro AL, et al. Chest imaging for pulmonary TB – an update. Semin Respir Crit Care Med. 2022;43:430-441.*
23. *Garlaschi G, et al. Diagnostic accuracy of chest radiography for the diagnosis of tuberculosis and its role in the detection of latent TB infection: a systematic review. J Rheumatol. 2014;41(Suppl 91):39-43.*
24. *Lu Y, Ling G, Qiang C, et al. PCR diagnosis of Pneumocystis pneumonia: a bivariate meta-analysis. J Clin Microbiol. 2012;50:1096-1102. doi:10.1128/JCM.06066-11.*
25. *Girodet PO, et al. Pneumocystis jirovecii pneumonia at chest high-resolution computed tomography in non-HIV immunocompromised patients: spectrum of findings and mimickers. Clin Radiol. 2019;74:860-867.*
26. *Alexander BD, et al. Diagnosis of invasive pulmonary aspergillosis: updates and recommendations. Clin Microbiol Infect. 2014;20(Suppl 6):80-89.*
27. *Zhou Y, et al. Imaging of pulmonary infection. In: Pulmonary Infections: Imaging and Clinical Correlation. Radiologic Clinics/Elsevier review literature. 2020.*
28. *Washington L, O'Sullivan-Murphy B, Christensen JD, McAdams HP. Radiographic Imaging of Community-Acquired Pneumonia: A Case-Based Review. Radiol Clin North Am. 2022;60:371-381. doi:10.1016/j.rcl.2022.01.011.*
29. *Washington L, O'Sullivan-Murphy B, Christensen JD, McAdams HP. Radiographic Imaging of Community-Acquired Pneumonia: A Case-Based Review. Infect Dis Clin North Am. 2024;38:19-33. doi:10.1016/j.idc.2023.12.008.*
30. *Self WH, Wunderink RG, Williams DJ, et al. Staphylococcus aureus community-acquired pneumonia: prevalence, clinical characteristics, and outcomes. Clin Infect Dis. 2016;63:300-309.*