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Original Research

Accuracy of Chest X-Ray versus CT in Detecting Solitary Pulmonary Nodules.

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Abstract

Background: Solitary pulmonary nodules (SPNs) are frequently encountered on thoracic imaging and may represent a wide spectrum of benign and malignant conditions. Early and accurate detection is essential because radiographic characteristics of an SPN may influence subsequent surveillance, further imaging, tissue diagnosis, and clinical management. Chest X-ray remains a widely available and economical initial imaging modality; however, its ability to detect small pulmonary nodules is limited by superimposition of anatomical structures and technical factors. Computed tomography (CT) provides cross-sectional imaging with superior spatial resolution and improved detection of pulmonary nodules. This study was undertaken to compare the diagnostic performance of chest X ray with CT in detecting SPNs at a tertiary care centre. **Aim:** To evaluate the accuracy of chest X-ray in comparison with computed tomography for the detection of solitary pulmonary nodules. **Methods:** A prospective comparative diagnostic accuracy study was conducted among 120 adult patients with clinical suspicion of pulmonary pathology or radiological suspicion of an SPN at a tertiary care centre in India over a period of 18 months. All eligible patients underwent standard chest radiography followed by CT of the chest. Chest X-ray findings were independently assessed for the presence, location, and approximate size of a pulmonary nodule. CT was used as the reference imaging standard for confirmation and detailed evaluation of SPNs. Diagnostic parameters including sensitivity, specificity, positive predictive value (PPV), negative predictive value (NPV), and overall accuracy of chest X-ray were calculated using CT findings as the reference standard. **Results:** Of the 120 patients evaluated, CT confirmed the presence of an SPN in 78 patients (65.0%). Chest X-ray identified an SPN in 61 patients, including 56 true-positive and 5 false-positive findings. Twenty-two CT-confirmed SPNs were not detected on chest X-ray. Chest X-ray demonstrated a sensitivity of 71.8%, specificity of 88.1%, PPV of 91.8%, NPV of 62.7%, and overall diagnostic accuracy of 77.5%. The detection rate of chest X-ray increased significantly with increasing nodule size. Chest X-ray detected most nodules measuring ≥ 10 mm, whereas CT demonstrated clear superiority for nodules measuring < 10 mm. CT additionally provided more accurate information regarding nodule margins, internal characteristics, calcification. **Conclusion:** Chest X-ray demonstrated moderate sensitivity for detecting SPNs but missed a substantial proportion of CT-confirmed nodules, particularly smaller lesions. CT showed superior diagnostic capability and remains the preferred imaging modality for confirmation and comprehensive characterization of suspected SPNs.

Keywords: Chest radiography; Computed tomography; Diagnostic accuracy; pulmonary nodule; Solitary pulmonary nodule.

Key Message: Chest X-ray remains useful as an initial imaging investigation, but CT is substantially more effective for confirming and characterizing solitary pulmonary nodules, particularly small or radiographically obscured lesions. Published evidence similarly indicates that chest radiographic detection is limited for small nodules, while CT provides substantially higher sensitivity for pulmonary nodule detection.

INTRODUCTION

Solitary pulmonary nodules (SPNs) are commonly encountered abnormalities in thoracic imaging and represent an important diagnostic challenge because they may arise from a broad spectrum of benign and malignant conditions [1]. An SPN is generally described as a single, approximately rounded pulmonary opacity measuring up to 3 cm in diameter, surrounded by lung parenchyma and without associated atelectasis, lymphadenopathy, or pleural effusion [2]. Accurate detection and subsequent characterization are clinically important because an SPN may represent an early manifestation of primary lung malignancy, while a substantial proportion of nodules are benign and require only appropriate surveillance [3,4].

Chest X-ray remains one of the most frequently performed imaging investigations for evaluating patients with respiratory symptoms and suspected thoracic disease. It is inexpensive, widely available, and associated with relatively low radiation exposure. Consequently, many pulmonary nodules are initially suspected or incidentally identified on routine chest radiography [5,6]. However, the diagnostic performance of chest X-ray for SPN detection is influenced by nodule size, location, radiographic density, technical quality, and superimposition of normal anatomical structures. Nodules located in the hilar regions, lung apices, retrocardiac areas, or adjacent to the diaphragm may be particularly difficult to identify on conventional radiographs [7,8].

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The limited sensitivity of chest radiography becomes particularly evident in smaller nodules. Conventional radiography may fail to demonstrate many nodules below 10 mm, and even relatively larger lesions may occasionally be obscured by overlying anatomical structures. Earlier evidence has demonstrated that CT has substantially greater sensitivity for pulmonary nodule detection and can identify lesions measuring only a few millimetres, thereby enabling earlier and more reliable detection than conventional chest radiography [9,10].

Computed tomography has transformed the evaluation of pulmonary nodules by providing cross sectional images with high spatial and contrast resolution. In addition to confirming the presence of a nodule, CT permits accurate assessment of its size, location, morphology, margins, attenuation, calcification, and relationship with adjacent structures [11]. CT can also identify additional nodules or associated thoracic abnormalities that may not be evident on chest X-ray. Notably, a proportion of patients considered to have a solitary lesion on chest radiography may demonstrate multiple pulmonary nodules on subsequent CT examination, which can substantially alter the diagnostic approach and differential diagnosis [12].

The clinical significance of accurate SPN detection extends beyond simple identification. Once a pulmonary nodule is confirmed, imaging findings contribute to risk stratification and decisions regarding interval surveillance, contrast-enhanced imaging, positron emission tomography, biopsy, or surgical intervention [13,14]. Although CT is the preferred modality for detailed evaluation, chest X-ray continues to play an important role as the initial imaging investigation in routine clinical practice, particularly in resource-constrained healthcare settings [15,16]. Understanding the diagnostic limitations of chest radiography in comparison with CT is therefore important for avoiding delayed diagnosis and inappropriate reassurance following a negative radiograph [17,18].

There is a need for institutionally relevant comparative data evaluating the performance of chest X ray against CT in the detection of SPNs. Such information may help quantify the proportion of lesions missed on conventional radiography and identify imaging or lesion-related factors associated with missed diagnoses. A prospective comparative diagnostic accuracy study conducted in a tertiary care setting can provide clinically relevant evidence regarding the practical performance of these commonly used imaging modalities [19,20].

Therefore, it is of interest to compare the accuracy of chest X-ray with computed tomography in detecting solitary pulmonary nodules at a tertiary care centre.

MATERIALS AND METHODS

Study Design and Setting

This prospective comparative diagnostic accuracy study was conducted in the Department of Radiodiagnosis of a tertiary care centre in India. The study was carried out over a period of 18 months. The study aimed to evaluate and compare the ability of chest X-ray and computed tomography (CT) to detect solitary pulmonary nodules (SPNs).

CT was considered the reference imaging modality for confirming the presence and detailed characteristics of pulmonary nodules because of its superior cross-sectional resolution and ability to detect small lesions that may not be visible on conventional chest radiography.

Study Population

A total of 120 consecutive eligible patients were included in the study. Adult patients referred for evaluation of suspected pulmonary abnormalities who underwent both chest X-ray and CT chest during the study period were assessed for eligibility.

The sample size of 120 was considered suitable for generating an adequately representative diagnostic accuracy dataset in a single-centre tertiary care setting and for permitting meaningful comparison of diagnostic performance across relevant clinical and radiological subgroups.

Inclusion Criteria

Patients fulfilling the following criteria were included:

- Patients aged 18 years and above.
- Patients with clinical or radiological suspicion of a pulmonary nodule.
- Patients undergoing both chest X-ray and CT chest as part of their diagnostic evaluation.
- Patients willing to provide written informed consent for participation in the study.

Exclusion Criteria

The following patients were excluded:

- Patients with diffuse pulmonary nodular disease or multiple pulmonary nodules at initial evaluation.
- Patients with a pulmonary mass measuring more than 3 cm in maximum diameter.
- Patients with inadequate or technically unsatisfactory chest radiographs.
- Patients with previous definitive surgical treatment for a pulmonary nodule before imaging evaluation.
- Pregnant patients, unless imaging was clinically indicated and appropriate institutional precautions were undertaken.
- Patients with incomplete imaging records or unavailable CT findings for comparison.

Study Procedure

After obtaining informed consent, relevant demographic and clinical information was recorded for each participant. All enrolled patients underwent standard chest radiography followed by CT examination of the chest as clinically indicated.

Chest X-ray images were assessed for the presence or absence of a suspected pulmonary nodule. When a nodule was identified, its approximate location, size, and radiographic characteristics were documented. The radiographic examination was interpreted without using the subsequent CT findings at the time of initial assessment.

CT images were subsequently evaluated for confirmation of the presence of an SPN. The location, maximum diameter, margins, attenuation, calcification, and associated thoracic findings were recorded. CT was also assessed for additional nodules or abnormalities that could alter the classification of an apparently solitary lesion detected on chest radiography.

The greater ability of CT to identify small nodules compared with projection chest radiography has been demonstrated in comparative imaging studies, particularly for lesions below 5-10 mm.

Chest X-Ray Technique

Standard digital chest radiography was performed using posteroanterior (PA) projection, with lateral views obtained where clinically indicated according to departmental protocol. Images were acquired during full inspiration with appropriate patient positioning.

The following findings were documented:

- Presence or absence of a suspected SPN.
- Anatomical location of the lesion.
- Approximate nodule size.
- Nodule density.
- Margin characteristics where appreciable.

- Presence of calcification where visible.
- Associated pulmonary or mediastinal abnormalities.

CT Chest Technique

CT examination of the thorax was performed using a multidetector CT scanner according to the institutional imaging protocol. Thin-section images were obtained and reviewed in appropriate lung and mediastinal window settings. Intravenous contrast was administered when clinically indicated but was not mandatory solely for inclusion in the study.

The following CT characteristics were assessed:

- Presence or absence of an SPN.
- Number of pulmonary nodules.
- Anatomical location.
- Maximum nodule diameter.
- Shape and margins.
- Attenuation characteristics.
- Presence and pattern of calcification.
- Cavitation, where present.
- Associated lymphadenopathy.
- Associated pleural or parenchymal abnormalities.

Patients in whom CT demonstrated multiple nodules rather than a truly solitary lesion were recorded separately for descriptive evaluation but were not considered CT-confirmed SPN cases for the primary diagnostic accuracy analysis.

Definition of Solitary Pulmonary Nodule

For the purpose of the study, an SPN was defined as a single, discrete, approximately rounded opacity within the lung parenchyma measuring up to 3 cm in maximum diameter and not associated with obvious atelectasis, pleural effusion, or significant hilar or mediastinal lymphadenopathy attributable to the lesion.

Reference Standard

CT chest was used as the reference imaging standard for the primary objective of determining the presence or absence of an SPN.

The diagnostic performance of chest X-ray was calculated against CT findings. This approach was specifically intended to evaluate the relative ability of chest radiography to detect nodules subsequently confirmed on CT. It should be distinguished from studies assessing whether a nodule is benign or malignant, for which histopathology or longitudinal follow-up is required as the definitive reference standard.

Outcome Measures

The primary outcome was the diagnostic accuracy of chest X-ray for detection of CT-confirmed SPNs.

The following parameters were calculated:

- **True positive (TP):** SPN detected on both chest X-ray and CT.
- **False positive (FP):** SPN suspected on chest X-ray but not confirmed on CT.
- **False negative (FN):** SPN not detected on chest X-ray but confirmed on CT.
- **True negative (TN):** No SPN detected on either chest X-ray or CT.

The following formulae were used:

Sensitivity (%) = TP / (TP + FN) × 100
Specificity (%) = TN / (TN + FP) × 100
Positive Predictive Value (%) = TP / (TP + FP) × 100
Negative Predictive Value (%) = TN / (TN + FN) × 100
Diagnostic Accuracy (%) = (TP + TN) / Total Number of Patients × 100

Statistical Analysis

Data were entered into a Microsoft Excel spreadsheet and analysed using appropriate statistical software. Continuous variables were expressed as mean $\pm$ standard deviation or median with interquartile range, depending on data distribution. Categorical variables were expressed as frequency and percentage.

Chest X-ray findings were compared with CT findings using a 2 $\times$ 2 diagnostic contingency table. Sensitivity, specificity, PPV, NPV, and overall diagnostic accuracy were calculated with corresponding 95% confidence intervals where applicable.

The association between chest X-ray detection and selected nodule characteristics, including nodule size and anatomical location, was analysed using the Chi-square test or Fisher's exact test, as appropriate. A P value <0.05 was considered statistically significant.

Ethical Considerations

The study was conducted after obtaining approval from the Institutional Ethics Committee. Written informed consent was obtained from all participants before enrolment. Patient confidentiality was maintained throughout the study, and all collected data were used solely for academic and research purposes.

Study Flow

A total of 120 patients underwent comparative evaluation with chest X-ray and CT chest. CT confirmed an SPN in 78 patients (65.0%), while 42 patients (35.0%) did not demonstrate an SPN on CT. The subsequent diagnostic accuracy analysis compared chest X-ray findings against these CT results.

This study framework is consistent with the central objective of comparing detection performance rather than diagnosing malignancy; CT-based and pathology-based diagnostic accuracy studies answer different clinical questions and should not be conflated.

RESULTS

A total of 120 patients who underwent both chest X-ray and CT chest for evaluation of suspected pulmonary abnormalities were included in the final analysis. The age of the study participants ranged from 18 to 82 years, with the majority belonging to the fifth and sixth decades of life. There was a slight male predominance. Cough was the most common presenting symptom, followed by breathlessness and chest pain, although a proportion of pulmonary nodules were detected incidentally during imaging performed for other clinical indications. CT chest

confirmed the presence of a solitary pulmonary nodule (SPN) in 78 of the 120 patients, corresponding to an overall prevalence of 65.0% in the study population. Chest X-ray demonstrated a suspected SPN in 61 patients, whereas CT provided more precise characterization regarding nodule size, location, margins, attenuation, and associated thoracic abnormalities. Of the 78 CT-confirmed SPNs, 56 were correctly identified on chest X-ray, while 22 nodules were missed. Five patients had radiographic findings suggestive of an SPN that were not confirmed on CT. The ability of chest X-ray to detect an SPN increased substantially with increasing nodule size, with smaller nodules accounting for most false-negative examinations. CT also demonstrated superior performance for nodules located in anatomically obscured regions, including the hilar, retrocardiac, and apical areas. The diagnostic performance analysis demonstrated moderate sensitivity but high specificity and positive predictive value for chest X-ray when CT was used as the reference imaging standard.

Table 1: Age Distribution of Study Participants

The majority of patients were aged between 51 and 70 years.

Age Group (Years)	Number of Patients (n=120)	Percentage
18-30	8	6.7
31-40	14	11.7
41-50	22	18.3
51-60	30	25.0
61-70	28	23.3
>70	18	15.0
Total	120	100.0

The mean age of the study participants was **56.4 ± 14.8 years**.

The study population predominantly consisted of middle-aged and elderly individuals, with 48.3% of patients aged 51-70 years. This age distribution is clinically relevant because the likelihood of detecting pulmonary nodules and the associated concern for malignant pathology generally increase with advancing age.

Table 2: Gender Distribution of Study Participants

A slight male predominance was observed.

Gender	Number of Patients (n=120)	Percentage
Male	68	56.7
Female	52	43.3
Total	120	100.0

Male participants constituted 56.7% of the study population, while females accounted for 43.3%, giving a male-to-female ratio of approximately 1.3:1.

Table 3: Presenting Clinical Features

Cough was the most frequent presenting clinical feature.

Clinical Feature*	Number of Patients	Percentage
Cough	64	53.3
Breathlessness	42	35.0
Chest pain	31	25.8
Fever	22	18.3
Hemoptysis	14	11.7
Weight loss	19	15.8
Incidental imaging finding	27	22.5

*Multiple clinical features were present in some patients.

Cough was the most commonly reported symptom, affecting 53.3% of participants. Notably, 22.5% of patients underwent further imaging following an incidental abnormality, highlighting the importance of imaging in identifying clinically unsuspected pulmonary lesions.

Table 4: Detection of Solitary Pulmonary Nodules on Chest X-Ray and CT

CT detected a higher number of SPNs compared with chest X-ray.

Imaging Finding	Chest X-Ray	CT Chest
SPN detected	61 (50.8%)	78 (65.0%)
SPN not detected	59 (49.2%)	42 (35.0%)
Total	120 (100.0%)	120 (100.0%)

CT chest confirmed SPNs in 65.0% of patients compared with a radiographic detection rate of 50.8%, demonstrating the superior capability of CT in detecting pulmonary nodules.

Table 5: CT Characteristics of Confirmed Solitary Pulmonary Nodules (n=78)

Most CT-confirmed SPNs measured between 10 and 20 mm and were located in the upper lobes.

Characteristic	Category	Number (n=78)	Percentage
Size	<5 mm	8	10.3
	5-9 mm	20	25.6
	10-20 mm	31	39.7
	21-30 mm	19	24.4
Location	Right upper lobe	20	25.6
	Right middle lobe	9	11.5
	Right lower lobe	15	19.2
	Left upper lobe	18	23.1
	Left lower lobe	16	20.5
Margin	Smooth	32	41.0

	Lobulated	21	26.9
	Spiculated	25	32.1
Calcification	Present	17	21.8
	Absent	61	78.2

The most frequent size category was 10-20 mm (39.7%), while upper-lobe nodules collectively accounted for 48.7% of CT-confirmed SPNs. Irregular or potentially suspicious margins, including lobulated and spiculated patterns, were observed in 59.0% of nodules.

Table 6: Chest X-Ray Detection Rate According to CT-Determined Nodule Size

The detection rate of chest X-ray increased significantly with increasing nodule size.

Nodule Size on CT	CT-Confirmed SPNs	Detected on Chest X-Ray	Detection Rate
<5 mm	8	1	12.5%
5-9 mm	20	8	40.0%
10-20 mm	31	28	90.3%
21-30 mm	19	19	100.0%
Total	78	56	71.8%

P < 0.001

Chest X-ray detection was strongly associated with nodule size. Only **12.5%** of nodules measuring <5 mm were detected radiographically, compared with complete detection of nodules measuring 21- 30 mm. This demonstrates the major limitation of chest X-ray in identifying small pulmonary nodules.

Table 7: Chest X-Ray Detection According to Location of CT-Confirmed SPNs

Chest X-ray detection varied according to the anatomical location of the nodule.

Location	CT-Confirmed SPNs	Detected on Chest X-Ray	Detection Rate
Right upper lobe	20	13	65.0%
Right middle lobe	9	7	77.8%
Right lower lobe	15	12	80.0%
Left upper lobe	18	12	66.7%
Left lower lobe	16	12	75.0%
Total	78	56	71.8%

P = 0.612

Although detection rates differed across anatomical locations, the association between location and chest X-ray detection was not statistically significant. Detection was relatively lower for upper-lobe nodules, where superimposition of clavicles and mediastinal structures may reduce conspicuity.

Table 8: Chest X-Ray Detection According to CT Margin Characteristics

Chest X-ray detection varied according to the morphological characteristics of SPNs.

Detection of Lung Cancer according to the morphological characteristics of CT TG.			
CT Margin	Is Detected on Chest X-Ray Detection Rate		
Smooth	32	20	62.5%
Lobulated	21	16	76.2%
Spiculated	25	20	80.0%
Total	78	56	71.8%

P = 0.286

Nodules with lobulated or spiculated margins demonstrated relatively higher radiographic detection rates than smooth nodules; however, this difference was not statistically significant. The observed difference may partly reflect the association of irregular morphology with larger lesion size.

Table 9: Comparison of Chest X-Ray Findings with CT Findings for SPN Detection

The diagnostic comparison was performed using CT as the reference imaging standard.

Chest X-Ray	SPN Present on CT	SPN Absent on CT	Total
SPN detected	56	5	61
SPN not detected	22	37	59
Total	78	42	120

Chest X-ray correctly identified 56 of 78 CT-confirmed SPNs, while 22 nodules were missed. Five patients had false-positive radiographic findings. The relatively high number of false-negative findings accounted for the moderate sensitivity of chest X-ray.

Table 10: Diagnostic Accuracy of Chest X-Ray for Detection of SPNs Using CT as Reference Standard

Diagnostic performance parameters were calculated from the 2 × 2 contingency table.

Diagnostic Parameter	Value
Sensitivity	71.8%
Specificity	88.1%
Positive Predictive Value	91.8%
Negative Predictive Value	62.7%
Overall Diagnostic Accuracy	77.5%

Chest X-ray demonstrated a sensitivity of 71.8% and an overall diagnostic accuracy of 77.5%. The high PPV indicates that most radiographically detected nodules were confirmed on CT. However, the lower NPV indicates that a negative chest X-ray could not reliably exclude the presence of an SPN.

Table 11: Overall Summary of Diagnostic Classification by Chest X-Ray

Most patients were correctly classified by chest X-ray; however, false-negative findings remained clinically significant.

Diagnostic Classification	Number (n=120)	Percentage
True positive	56	46.7
True negative	37	30.8
False positive	5	4.2
False negative	22	18.3
Total	120	100.0

Overall, 93 patients (77.5%) were correctly classified by chest X-ray. False-negative examinations constituted 18.3% of all cases and represented the principal limitation of chest radiography in this study.

Summary of Results

Table 1 demonstrated that the study population predominantly consisted of patients aged 51-70 years, with a mean age of 56.4 years. **Table 2** showed a slight male predominance. **Table 3** identified cough as the most common presenting symptom, while a considerable proportion of lesions were detected incidentally. **Table 4** demonstrated that CT detected substantially more SPNs than chest X-ray. **Table 5** described the CT characteristics of confirmed SPNs, with most nodules measuring 10-20 mm and upper-lobe involvement being common. **Table 6** demonstrated a statistically significant association between increasing nodule size and radiographic detection, with chest X-ray performing poorly for nodules below 10 mm. **Table 7** showed variation in detection according to anatomical location, although the association was not statistically significant. **Table 8** demonstrated no significant association between CT margin characteristics and chest X-ray detection. **Table 9** provided the primary diagnostic contingency analysis and showed that 22 CT-confirmed SPNs were missed on chest X-ray. **Table 10** demonstrated a sensitivity of 71.8%, specificity of 88.1%, PPV of 91.8%, NPV of 62.7%, and overall diagnostic accuracy of 77.5%. **Table 11** confirmed that false-negative findings were the principal source of diagnostic limitation with chest X-ray. Overall, the findings establish the superior role of CT in detecting and comprehensively evaluating SPNs, particularly small lesions that may remain occult on conventional chest radiography.

DISCUSSION

The present prospective comparative diagnostic accuracy study evaluated the performance of chest X-ray in detecting solitary pulmonary nodules using CT chest as the reference imaging standard. Among the 120 patients evaluated, CT confirmed an SPN in 78 patients (65.0%), whereas chest X-ray detected a suspected nodule in 61 patients (50.8%). Chest X-ray correctly identified 56 of the 78 CT-confirmed nodules and missed 22 lesions. The findings demonstrate the inherent limitation of projection radiography in the detection of pulmonary nodules and reinforce the superior diagnostic capability of CT for identifying and characterizing focal pulmonary lesions [1,2].

The mean age of the study population was 56.4 ± 14.8 years, with the majority of patients belonging to the fifth through seventh decades of life. A slight male predominance was observed. Cough was the most common presenting symptom, although a substantial proportion of abnormalities were detected incidentally [3]. This observation is clinically important because pulmonary nodules are frequently identified during imaging performed for symptoms unrelated to the nodule itself or during evaluation of other thoracic conditions. Therefore, an imaging modality capable of reliably confirming and characterizing these lesions is essential for appropriate subsequent management [4].

In the present study, chest X-ray demonstrated a sensitivity of 71.8%, specificity of 88.1%, positive predictive value of 91.8%, negative predictive value of 62.7%, and overall diagnostic accuracy of 77.5%. The high positive predictive value indicates that a discrete radiographic opacity considered suspicious for an SPN was frequently confirmed on CT [5]. However, the relatively low negative predictive value is clinically more relevant because a negative chest X-ray did not reliably exclude the presence of a pulmonary nodule. Thus, chest radiography may serve as an initial imaging examination but should not be regarded as sufficiently sensitive to rule out an SPN when clinical suspicion remains high [6].

The principal reason for the reduced sensitivity of chest X-ray was the limited detection of small nodules. Only one of the eight nodules measuring less than 5 mm was identified on chest X-ray, corresponding to a detection rate of 12.5%. Similarly, only 40.0% of nodules measuring 5-9 mm were detected. In contrast, the detection rate increased to 90.3% for nodules measuring 10-20 mm and reached 100% for nodules measuring 21-30 mm. The statistically significant association between nodule size and radiographic detection confirms that lesion size is a major determinant of the performance of conventional chest radiography [7,8]. These findings are consistent with established radiological understanding that many small pulmonary nodules are not visible on chest radiographs. The Fleischner Society has emphasized the importance of accurate CT-based measurement and characterization of pulmonary nodules, and its guidance notes that most nodules smaller than 1 cm are not visible on chest radiographs. CT, particularly with thin section acquisition and multiplanar reconstruction, permits more reliable detection and measurement of small lesions than projection radiography [9].

The anatomical location of an SPN can also influence its visibility on chest X-ray. In the present study, radiographic detection was relatively lower for upper-lobe lesions than for lesions in several other pulmonary locations, although the association between location and detection was not statistically significant. Nodules located near the clavicles, hila, mediastinum, heart, or diaphragm may be obscured by overlying structures on conventional radiographs. This represents a fundamental limitation of two-dimensional projection imaging. CT eliminates much of this problem by providing cross-sectional visualization of the lung parenchyma [10,11].

CT also provided substantially more information than simple confirmation of the presence of an SPN. The examination allowed assessment of lesion size, exact anatomical location, margin characteristics, attenuation, calcification, and associated thoracic abnormalities. [12]. Margin characteristics were also assessed in the present study. Smooth margins were observed in 41.0% of CT-confirmed nodules, whereas lobulated and spiculated margins together accounted for 59.0%. Although chest X-ray detection appeared relatively greater for nodules with lobulated or spiculated margins, this association was not statistically significant. The ability of CT to characterize margins is particularly valuable because morphology contributes to radiological risk assessment. Nevertheless, imaging morphology alone cannot definitively establish the biological nature of every pulmonary nodule [13,14].

The present findings have direct implications for clinical practice. Current appropriateness guidance recommends CT chest without intravenous contrast as the usually appropriate next imaging examination in adults with an incidentally detected indeterminate pulmonary nodule on chest radiography. This recommendation is consistent with the findings of the present study, in which CT identified a substantial number of nodules that were not recognized on chest X-ray and provided detailed lesion characterization [15]. The role of CT becomes particularly important when a pulmonary nodule requires risk stratification and follow-up. International guidance for incidentally detected pulmonary nodules is primarily based on CT findings, including nodule size, morphology, and clinical risk factors. The Fleischner Society recommendations provide a structured approach to the management of incidentally detected nodules and emphasize CT-based evaluation for appropriate characterization and surveillance. Therefore, once a nodule is suspected clinically or radiographically, CT can provide the detailed information required for rational decision-making [16,17].

An important strength of the present study was the prospective comparative design, in which all included participants underwent both imaging modalities. This permitted direct assessment of chest X-ray findings against CT results and allowed calculation of clinically meaningful diagnostic accuracy parameters. The inclusion of size-wise and location-wise analyses also demonstrated the specific circumstances in

which chest radiography was most likely to fail [18]. The study also has certain limitations. First, it was conducted at a single tertiary care centre, and the findings may not be completely generalizable to all healthcare settings. Second, CT was used as the reference imaging standard for detection of an SPN rather than histopathology. This was appropriate for the primary objective of determining whether chest X-ray could detect a CT-confirmed pulmonary nodule, but it does not establish whether the detected nodules were benign or malignant. Third, the relatively high proportion of patients with CT-confirmed nodules reflects the selected tertiary-care population and should not be interpreted as the prevalence of SPNs in the general population. Finally, observer variability and differences in radiographic image quality may influence the detection of subtle nodules [19,20].

Despite these limitations, the present study clearly demonstrates that chest X-ray has an important but restricted role in SPN detection. Its advantages include wide availability, lower cost, rapid acquisition, and relatively low radiation exposure. However, these advantages must be balanced against its limited sensitivity for small or anatomically obscured nodules. CT offers markedly superior lesion detection and provides comprehensive anatomical and morphological information necessary for further evaluation. Overall, the findings support a practical imaging approach in which chest X-ray may identify an initial abnormality, but CT should be performed when an indeterminate pulmonary nodule is suspected or when clinical suspicion persists despite a non-diagnostic radiograph. This approach minimizes the risk of missed lesions and facilitates appropriate characterization, surveillance, and further diagnostic intervention when required.

CONCLUSION

Chest X-ray demonstrated moderate sensitivity and overall diagnostic accuracy for the detection of solitary pulmonary nodules when compared with CT chest. Although chest radiography showed high specificity and positive predictive value, it missed a clinically significant proportion of CT-confirmed nodules, particularly those measuring less than 10 mm. CT proved superior not only in detecting pulmonary nodules but also in accurately determining their size, location, margins, internal characteristics. Current imaging guidance likewise recognizes CT as the primary modality for characterization and follow-up of indeterminate pulmonary nodules.

Therefore, chest X-ray may be useful as an initial imaging investigation, but a negative radiograph should not exclude the possibility of an SPN when clinical or radiological suspicion persists. CT chest should be considered the preferred modality for confirmation and comprehensive evaluation of suspected solitary pulmonary nodules. This is particularly important because most nodules smaller than 1 cm may not be visible on chest radiographs.

Limitations

The present study was conducted at a single tertiary care centre, which may limit the generalizability of the findings. CT was used as the reference imaging standard for determining the presence of an SPN; therefore, the study evaluated detection accuracy rather than the ability of imaging to differentiate benign from malignant nodules. Histopathological confirmation was not available for all detected nodules. In addition, observer-related variation and differences in chest radiographic image quality may have influenced the detection of subtle lesions.

Recommendations

- Chest X-ray should continue to be used as an initial and readily available thoracic imaging modality.
- CT chest should be performed for confirmation and detailed characterization of suspected or indeterminate pulmonary nodules.
- A negative chest X-ray should not be considered sufficient to exclude an SPN in patients with persistent clinical suspicion.
- Particular attention should be given to small nodules and lesions situated in anatomically obscured regions.
- Larger multicentric studies incorporating histopathological correlation and longitudinal follow-up may provide further evidence regarding the complete diagnostic pathway and clinical outcomes of patients with SPNs.

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Nil.

Conflicts of Interest

There are no conflicts of interest.

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