The Egyptian Journal of Hospital Medicine (July 2025) Vol. 100, Page 3729-3737

Diagnostic Value of I-Scan Bronchoscopy in Comparison to White Light Bronchoscopy in Suspected Lung Cancer Patients

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ABSTRACT

Background: Lung cancer is a major cause of cancer-related mortality, with prognosis dependent on early, accurate diagnosis. White light bronchoscopy (WLB) is a standard diagnostic tool but has limited sensitivity for early or subtle lesions. I-scan bronchoscopy, an image-enhanced endoscopic technique, improves mucosal and vascular visualization, potentially increasing diagnostic yield. **Objective:** To compare the diagnostic value of I-scan bronchoscopy with WLB in suspected lung cancer and assess the benefit of combining both.

Methods: A cross-sectional study was conducted on 60 patients (mean age 61.37 ± 11.83 years; 73.3% males) with clinical and radiological suspicion of lung cancer. Each patient underwent sequential WLB followed by I-scan bronchoscopy using a PENTAX EPK-i5000 system. Lesions were graded using predefined criteria, and targeted biopsies were histologically examined. Sensitivity, specificity, predictive values, and overall accuracy were compared.

Results: Histopathology confirmed malignancy in 45 patients (75%) and benign pathology in 15 (25%). I-scan upgraded 40% of lesions initially graded low suspicion by WLB. For bronchoscopic grade 3–4 lesions, I-scan showed higher sensitivity (73.3% vs. 64.4%) with equal specificity (86.7%). In non-endobronchial lesions, sensitivity was markedly higher (76% vs. 36%), though specificity was slightly lower (78.6% vs. 92.9%). Negative predictive value improved from 44.8% with WLB to 90.7% with I-scan. Complications were minimal, with bleeding most common (38.3%).

Conclusion: I-scan bronchoscopy enhances detection of early and subtle bronchial lesions compared with WLB, offering higher sensitivity and markedly improved negative predictive value, which may reduce missed diagnoses and unnecessary repeat procedures in high-risk patients.

Keywords: I-Scan Bronchoscopy, White Light Bronchoscopy, lung cancer.

INTRODUCTION

Cancer remains a leading cause of mortality worldwide, responsible for approximately 10 million deaths in 2020, with lung cancer ranking second in incidence, accounting for 2.21 million cases annually[(1)]. The history of bronchoscopy dates back to 1898, when Gustav Killian performed the first rigid bronchoscopy in Germany[(2)]. In the late 1960s, Shigeto Ikeda introduced fibreoptic bronchoscopy (FOB), which rapidly became the cornerstone for diagnosing suspected lung cancer[(3)]. Bronchoscopy not only facilitates histopathological diagnosis but also contributes to disease staging and therapeutic interventions[(4)]. Flexible video bronchoscopy allows visualization of up to sixth-order bronchi, enabling assessment of mucosal colour, vascularity, and structural changes, and is widely used to investigate abnormal imaging findings and obtain tissue biopsies[(5)].

I-scan technology, developed by PENTAX (Japan), represents an advanced image-enhanced endoscopy modality that produces bright images comparable to conventional white light bronchoscopy (WLB) without requiring magnification[(6)].

It provides real-time virtual chromoendoscopy through three enhancement modes: surface enhancement (SE), contrast enhancement (CE), and tone enhancement (TE), each optimizing the visualization of specific anatomical features[(7)]. Clinical studies indicate that i-scan bronchoscopy improves detection of abnormal vascular and preinvasive lesions, thereby increasing diagnostic accuracy in lung cancer compared with WLB[(8)]. This study aimed to evaluate the diagnostic value of i-scan bronchoscopy compared with white light bronchoscopy in the early detection of lung cancer and its potential to improve patient outcomes.

PATIENTS AND METHOD

Setting of the Study

This study was conducted at the Bronchoscopic Unit of the Chest Department, Zagazig University Hospitals, over a 12-month period from April 2022 to April 2023. All participants provided written informed consent before inclusion, in accordance with institutional and ethical guidelines.

Study Design: A cross-sectional comparative study design was employed to evaluate the diagnostic performance of i-scan bronchoscopy compared with conventional white light bronchoscopy (WLB) in patients with suspected lung cancer.

Patients

The study included 60 patients aged between 20 and 78 years who presented with clinical and radiological suspicion of lung cancer. Clinical suspicion was based on symptoms such as hemoptysis, persistent cough, hoarseness of voice, weight loss, anorexia, dyspnea, unexplained chest pain, or digital clubbing, while radiological suspicion was based on chest X-ray or computed tomography (CT) findings including solitary pulmonary nodules (<3 cm), lung masses (>3 cm), multiple nodules, unresolved pneumonia or pleural effusion, and mediastinal lymphadenopathy. Patients

Received: 24/04/2025
Accepted: 23/06/2025

presenting with features suggestive of paraneoplastic syndromes, unexplained thromboembolism, or metastases were also considered eligible.

Inclusion and Exclusion Criteria

Inclusion criteria comprised patients with both clinical and radiological suspicion of lung cancer. Exclusion criteria included those unfit for bronchoscopy due to severe respiratory insufficiency (PaO_2 < 60 mmHg despite oxygen therapy, $PaCO_2$ > 50 mmHg), unstable cardiovascular or hemodynamic status, severe pulmonary hypertension, coagulation disorders (prothrombin concentration < 60%, platelet count < 60,000/mm³), uncontrolled comorbidities such as diabetes mellitus and hypertension, recent head or neck trauma or surgery, or upper airway obstruction such as stridor or laryngeal edema.

Sample Size

Sample size calculation was based on an assumed frequency of diffuse lesions of 45.5% in i-scan positive cases compared with 10.3% in i-scan negative cases. Using a power of 80% and a 95% confidence interval, the estimated sample size was determined to be 60 patients, calculated via OpenEpi software.

Operational Design

Pre-Procedure Evaluation

All patients underwent a detailed history and examination. Demographic information, occupational exposures, and smoking history were recorded. Past medical history, including previous tuberculosis or malignancy, and family history of lung disease were noted. Clinical examination included a thorough general assessment and focused respiratory system evaluation. Radiological investigations comprised chest X-ray for preliminary assessment and contrast-enhanced CT of the chest to evaluate lesion characteristics, staging, and optimal biopsy approach. Laboratory investigations included complete blood count, erythrocyte sedimentation rate, liver and kidney function tests, coagulation profile, and viral serology for hepatitis B, hepatitis C, and HIV. Electrocardiography and arterial blood gas analysis were performed to assess cardiopulmonary status.

Patient Preparation

Patients fasted for 4–6 hours before bronchoscopy. The procedure was explained in detail to ensure patient cooperation, particularly when performed under local anesthesia with conscious sedation. In the bronchoscopy suite, standard monitoring with ECG and pulse oximetry was instituted, and supplemental oxygen was administered to maintain oxygen saturation above 90%.

Bronchoscopy Procedure

Bronchoscopy was performed using a **PENTAX Medical EPK-i5000** video bronchoscope under local anesthesia and conscious sedation. Local anesthesia consisted of 2% lidocaine spray to both nostrils, oral cavity, and vocal cords, while conscious sedation was achieved with intravenous midazolam in doses ranging from 5–10 mg. The nasal or oral route was used according to patient anatomy, and the bronchial tree was systematically examined to the subsegmental level.

White Light Bronchoscopy (WLB)

Initial examination was performed under WLB. Findings were categorized into: Grade 1 – normal mucosa; Grade 2 – abnormal but not suspicious (erythema, swelling, granulation tissue); Grade 3 – suspicious for intraepithelial neoplasia (nodularity, mucosal irregularity, subcarinal thickening); Grade 4 – visible endobronchial tumor.

I-Scan Bronchoscopy

Following WLB, i-scan bronchoscopy was conducted using three enhancement modes: surface enhancement, contrast enhancement, and tone enhancement. Suspicious lesions were graded as: Grade 1 – normal vascularity; Grade 2 – abnormal vascularity with <3 suspicious criteria; Grade 3 – suspicious with ≥3 suspicious criteria; Grade 4 – visible tumor.

Biopsy Technique

Targeted biopsies were performed using reusable fenestrated forceps (Olympus FB-21C or FB-52C-1), obtaining 3–5 specimens per lesion. Samples were immediately fixed in formalin for histopathological examination. Histological evaluation included assessment of crush artifact (none, 1+ < 5%, 2+ = 5–25%, 3+ > 25%) and interpretability (mild, moderate, severe).

Post-Procedure Care

Biopsy sites were inspected for bleeding and managed with cold saline, topical adrenaline, or cautery as required. Post-procedure chest X-ray was obtained to exclude pneumothorax. Complications, including hemoptysis, pneumothorax, shock, or death, were documented, as was the length of post-procedure hospital stay.

Ethical Considerations

The study protocol was approved by the Institutional Review Board of Zagazig University (IRB-ZU: 9479-10-4-2022) after departmental approval. Written informed consent was obtained from all participants. Patient confidentiality was maintained, and data were used solely for research purposes.

Statistical Analysis

Statistical analysis was conducted utilizing SPSS software version 24.0. Continuous data were reported as mean ± standard deviation, while categorical variables were described using counts and percentages. Intergroup comparisons for categorical variables employed the Chi-square or Fisher's exact test, as indicated, whereas differences in continuous variables were assessed by independent t-test. For ordinal data, the Chi-square test for trend was utilized. Concordance between grading by white light bronchoscopy and I-scan bronchoscopy was determined using Cohen's kappa statistic. Diagnostic efficacy of bronchoscopic techniques was further evaluated through calculation

of sensitivity, specificity, positive and negative predictive values (PPV, NPV), and overall accuracy. A p-value <0.05 was considered statistically significant.

RESULTS

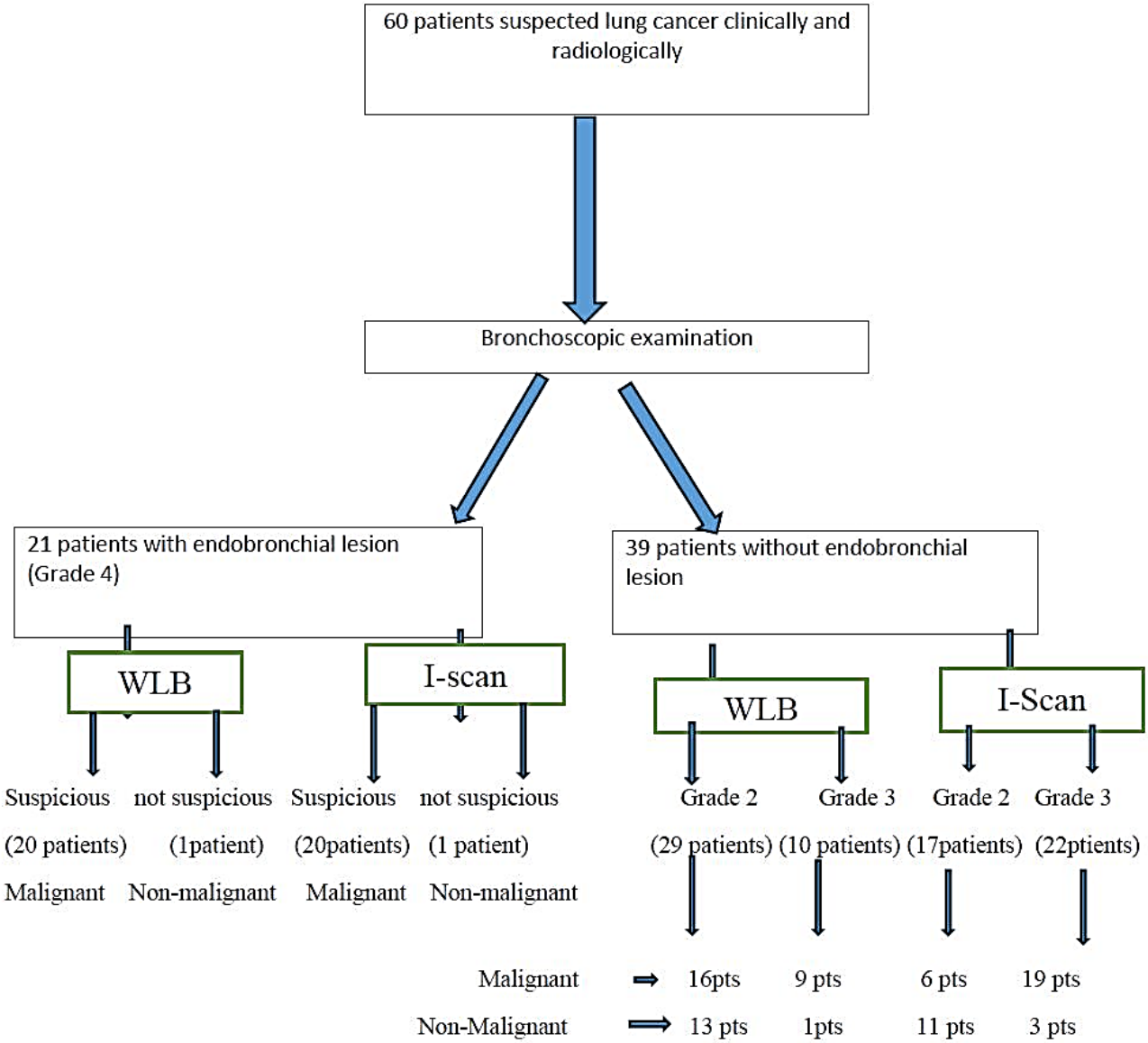

Figure 1: Consort flowchart.

This study included 60 patients with age range from 20 to 78 years with mean age 61.37 years. Male represented 73.3% of patients. About 48% were current smokers. More than half of the studied patients had no comorbidities, 20% and 16.7% of patients had comorbid hypertension and diabetes. About 78% of patients tested negative for both hepatitis B and C.

Table (1) Distribution of the studied patients according to baseline data:

	N=60	%
Gender		
Female	16	26.7%
Male	44	73.3%
Smoking		
Non-smokers	19	31.7%
Ex-smoker	12	20%
Current smokers	29	48.3%
Comorbidity		
Free	31	51.7%
Hypertensive	12	20%
Diabetes	10	16.7%
Cardiac	6	19%
COPD	10	16.7%
Old stroke	2	3.3%
Viral markers		
Free	47	78.3%
HBV positive	2	3.3%
HCV positive	11	18.4%
	Mean ± SD	**Range**
Age (year)	61.37 ± 11.83	20 – 78

According to CT; 50% had upper lobe affected; 56.7% had unilateral right-sided lesion; 55% had mass, 28.3%, 11.7% and 10% had consolidation, collapse and lymphadenopathy respectively.

Table (2) Distribution of the studied patients according to CT chest:

	N=60	%
Side		
Right	39	56.7%
Left	19	36.7%
Bilateral	2	3.3%
CT findings		
Mass	33	55%
Consolidation	17	28.3%
Collapse	7	11.7%
Lymphadenopathy	6	10%
Effusion	5	8.3%
Abscess	3	5%
Shift mediastinum	3	5%

While 29 patients were classified as grade 2 by white light bronchoscopy, number became 17 after application of I-scan bronchoscopy. While 10 patients were classified as grade 3 by white light bronchoscopy, number became 22 after application of I-scan bronchoscopy. Number of patients with grade 4 did not change when use white light bronchoscopy or I-scan bronchoscopy. There is significant substantial agreement between both

Table (3) Distribution of the studied patients according to white light bronchoscopy and I-bronchoscopy findings:

	White light bronchoscopy		I-scan bronchoscopy	
	N=60	**%**	**N=60**	**%**
Grade				
Grade 2 abnormal	29	48.3%	17	28.3%
Grade 3 suspicious	10	16.7%	22	36.7%
Grade 4 tumor	21	35%	21	35%
Kappa	0.701	P=<0.001**		

Kappa 0.6 to 0.8 means substantial agreement

Table (4) Forty-five patients had malignant lesions in form of adenocarcinoma (15 patients), squamous cell carcinoma (16 patients) and small cell carcinoma (10 patients) and two patients had round cell carcinoma. Thirteen patients had chronic non-specific bronchitis (21.6%) and one patient had squamous cell metaplasia

Table (4) Distribution of the studied patients according to histopathology:

	N=60	%
Nature		
Non-malignant	15	25%
Malignant	45	75%
Findings		
Chronic non-specific bronchitis	13	21.6%
Granulation tissue	1	1.7%
Adenocarcinoma	15	25%
Mucoid adenocarcinoma	1	1.7%
Papillary adenocarcinoma	1	1.7%
Squamous metaplasia	1	1.7%
Squamous cell carcinoma	16	26.7%
Small cell carcinoma	10	16.7%
Round cell carcinoma	2	3.3%

No statistically significant associations were identified between the histopathological type of lesion and patient age, gender, comorbidities, viral markers, or most presenting respiratory symptoms, including cough, expectoration, breathlessness, or weight loss. In contrast, significant correlations were observed between malignancy and current smoking status, as well as the presence of diabetes and COPD, with all patients exhibiting these comorbidities found to have malignant pathology. Additionally, hoarseness of voice, hemoptysis, and digital clubbing were significantly more prevalent among patients with malignant lesions.

Table (5) Relation between nature of lesion and clinical data of studied patients

	Non-malignant N=15 (%)	**Malignant N=45 (%)**	χ^2	p
Gender				
Female	5 (33.3%)	11 (24.4%)	0.455	0.5
Male	10 (66.7%)	34 (75.6%)		
Smoking				
Non-smokers	8 (33.3%)	11 (31.1%)		
Ex-smoker	4 (26.7%)	8 (17.8%)	6.367¥	0.012*
Current smokers	3 (40%)	26 (51.1%)		
	Mean ± SD	**Mean ± SD**	t	p
Age (year)	61.07 ± 12.53	61.47 ± 11.73	-0.112	0.911
Comorbidity				
COPD	0 (0%)	10 (22.2%)	4.0	0.046*
Diabetes	0 (0%)	10 (22.2%)	4	0.046*
Hypertensive	5 (33.3%)	7 (15.6%)	2.222	0.136
Cardiac	1 (6.7%)	5 (11.1%)	Fisher	>0.999
Old stroke	1 (6.7%)	1 (2.2%)	Fisher	0.514
Free	9 (60%)	22 (48.9%)	0.556	0.456
Viral markers				
Free	11 (73.3%)	36 (80%)		
HBV positive	0 (0%)	2 (4.4%)	1.488	0.475
HCV positive	4 (26.7%)	7 (15.5%)		
Cough	11 (73.3%)	35 (77.8%)	0.124	0.724
Expectoration	8 (53.3%)	28 (62.2%)	0.37	0.543
Breathlessness	14 (93.3%)	43 (95.6%)	0.117	0.732
Hemoptysis	4 (26.7%)	30 (66.7%)	Fisher	0.014*
Weight loss	7 (46.7%)	29 (64.4%)	1.481	0.224
Hoarseness of voice	1 (6.7%)	17 (37.8%)	Fisher	0.025*
Clubbing	0 (0%)	14 (31.1%)	Fisher	0.013*
Dysphagia	2 (13.3%)	12 (26.7%)	Fisher	0.483

Table (6) shows that masses are the most common CT finding in both groups, Consolidation is seen more in non-malignant cases, but collapse, lymphadenopathy, effusion and abscess are relatively in frequent in both groups. There is statistically non-significant relation between histopathological nature and CT findings.

Table (6) Relation between nature of lesion and CT findings of studied patients

	Non-malignant N=15 (%)	**Malignant N=45 (%)**	χ^2	p
Laterality				
Unilateral	15 (100%)	43 (95.6%)	Fisher	>0.999
Bilateral	0 (0%)	2 (4.4%)		
CT findings				
Mass	7 (46.7%)	26 (57.8%)	0.561	0.454
Consolidation	6 (40%)	11 (24.4%)	1.341	0.247
Collapse	1 (6.7%)	6 (13.3%)	Fisher	0.668
Lymphadenopathy	1 (6.7%)	5 (11.1%)	Fisher	>0.999
Effusion	0 (0%)	5 (11.1%)	1.818	0.178
Abscess	1 (6.7%)	2 (4.4%)	Fisher	>0.999
Shift mediastinum	0 (0%)	3 (6.7%)	Fisher	0.566

χ^2Chi square test ¥Chi square for trend test t independent sample t test

A statistically significant association was observed between the histopathological diagnosis and bronchoscopy findings, with grade 4 tumors detected in 44.4% of malignant cases compared to only 6.7% of non-malignant cases.

Table (7) Relation between histopathological nature of biopsies and findings of white light bronchoscopy:

	Non-malignant N=15 (%)	Malignant N=45 (%)	χ^2	p
White light bronchoscopy				
Grade 2 abnormal	13 (86.7%)	16 (35.6%)	10.718	0.001**
Grade 3 suspicious	1 (6.7%)	9 (20%)		
Grade 4 tumor	1 (6.7%)	20 (44.4%)		

A statistically significant correlation was found between the histopathological nature of the lesion and both conventional bronchoscopy and I-scan bronchoscopy findings, as grade 4 tumors were identified in 44.4% of malignant cases compared to only 6.7% among non-malignant cases for each modality.

Table (8) Relation between histopathological nature and findings of I-scan bronchoscopy:

	Non-malignant N=15 (%)	Malignant N=45 (%)	χ^2	p
I-scan bronchoscopy				
Grade 2 abnormal	11 (73.3%)	6 (13.3%)		
Grade 3 suspicious	3 (20%)	19 (42.2%)	16.817	0.001**
Grade 4 tumor	1 (6.7%)	20 (44.4%)		

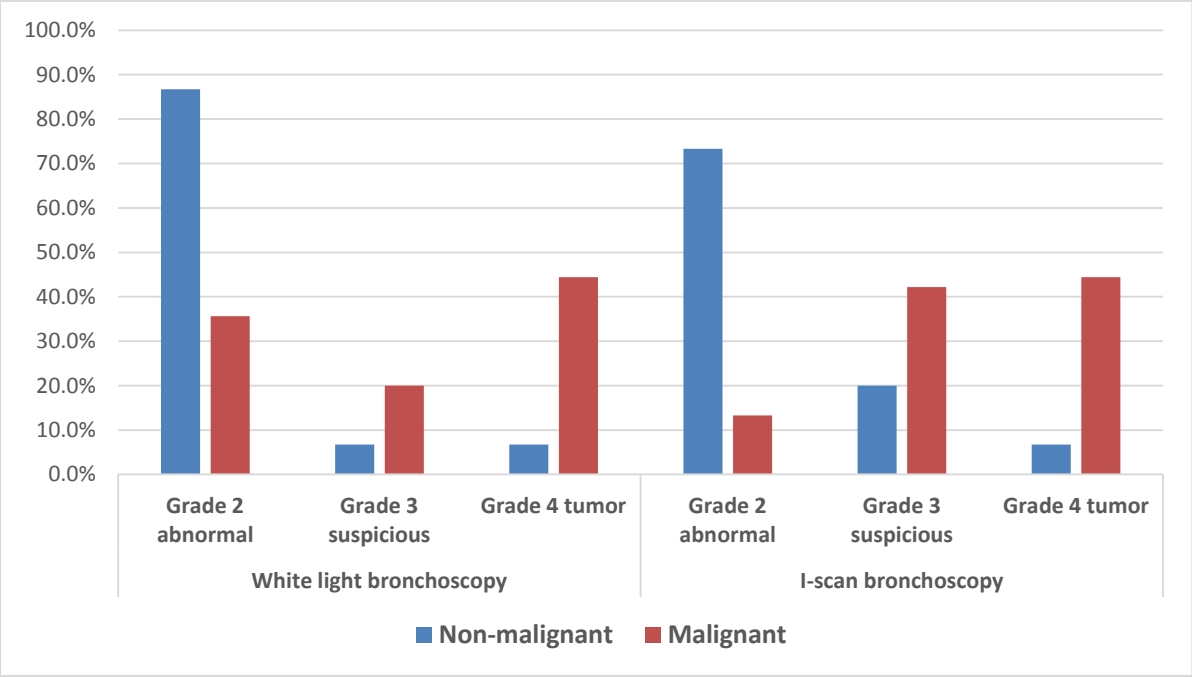

Figure (2): Multiple bar chart showing relation between histopathological nature and findings of white light bronchoscopy and I-scan bronchoscopy.

Grade 3 by white light bronchoscopy can predict non-endobronchial malignant lesions with sensitivity 36%, specificity 92.9%, positive, negative predictive value and overall accuracy 90%, 44.8% and 65.4% respectively. Grade 3 by I-scan bronchoscopy can predict non-endobronchial malignant lesions with sensitivity 76%, specificity 78.6%, positive, negative predictive value and overall accuracy 86.4%, 64.7% and 76.9% respectively

Table (9) Performance of non-endobronchial bronchoscopic grade 3 in diagnosis of malignant lesions:

Set	Sensitivity	Specificity	PPV	NPV	Accuracy	p
White light bronchoscopy	**36%**	**92.9%**	**90%**	**44.8%**	**65.4%**	**0.064**
I-scan bronchoscopy	**76%**	**78.6%**	**86.4%**	**64.7%**	**76.9%**	**0.002***

PPV positive predictive value, NPV negative predictive value.

DISCUSSION

Lung cancer remains one of the leading causes of cancer-related morbidity and mortality worldwide. Early and accurate diagnosis is critical for improving treatment outcomes and overall survival [9]. Bronchoscopy is a cornerstone in the diagnostic workup of suspected lung cancer, traditionally performed using white light bronchoscopy (WLB). However, WLB has certain limitations, particularly in detecting premalignant or subtle mucosal lesions that may not be easily visualized under standard illumination [10].

In recent years, advances in endoscopic imaging have introduced enhanced technologies such as I-scan bronchoscopy, a form of digital image-enhancement technique that improves mucosal surface and vascular pattern visualization. I-scan technology provides real-time image processing by enhancing contrast and sharpness, potentially allowing for earlier and more accurate detection of neoplastic changes [11]. This study aimed to compare I-scan bronchoscopy with white light bronchoscopy in patients suspected of having lung cancer. It also aimed to validate the findings of I-scan bronchoscopy in relation to the histopathological results of biopsies and to assess the added diagnostic value of combining I-scan bronchoscopy with white light bronchoscopy.

The present study included patients with suspected lung cancer, with a mean age of 61.37 ± 11.83 years and an age range of 20-78 years. The predominance of male patients (73.3%) and the high prevalence of current smokers (48.3%) align with established epidemiological patterns of lung cancer. There was no statistically significant relation between histopathological nature and either age or gender, but there was a statistically significant relation between histopathological nature and smoking, with current smoking associated with malignant lesions. **Tawfik *et al.*** [12] reported a statistically significant difference in smoking rates between individuals with cancerous tumors and those without (77.3%).

These demographic characteristics are consistent with **Fouda *et al.*** [8] who demonstrated the higher incidence of lung cancer among elderly males (77.5%) with significant smoking histories. The mean age in our study corresponds closely to the typical age of lung cancer diagnosis, as most cases occur in patients over 60 years of age. The substantial representation of current and former smokers (68.3% combined) in our study population reflects the well-established causal relationship between tobacco use and lung cancer development. This demographic profile is particularly relevant when evaluating the effectiveness of bronchoscopic diagnostic techniques, as smoking-related changes in bronchial mucosa can potentially affect the accuracy of visual inspection methods.

The clinical criteria suspicious for lung cancer in this study were consistent with established literature. Breathlessness was the most common presenting symptom (95%), followed by cough (76.7%), expectoration (60%), weight loss (60%), and hemoptysis (56.7%). There was a statistically significant relation between histopathological nature and the presence of hoarseness of voice, hemoptysis, and clubbing (all significantly higher among patients with malignant lesions). In line with our findings, **Davis *et al.*** [13], **Moore *et al.*** [14] **and Vesel *et al.*** [15] also reported breathlessness as the most frequent symptom.

In contrast, hemoptysis was reported as the most common symptom by **Vincent *et al.*** [16] **Fouda *et al.*** [8] **and Tawfik *et al.*** [12]**.** The statistical analysis in our study revealed that hoarseness, hemoptysis, and clubbing were significantly more prevalent among patients with malignant lesions ($p<0.05$). These features are clinically relevant, as hoarseness may indicate recurrent laryngeal nerve involvement by mediastinal lymphadenopathy or tumor extension; hemoptysis may result from vascular erosion; and clubbing is often a paraneoplastic manifestation of non-small cell lung cancer. There was no significant relation between histopathological nature and cough, expectoration, breathlessness, weight loss, or dysphagia. **Tawfik *et al.*** [12] reported that cough, dyspnea, hemoptysis, chest discomfort, and toxic symptoms did not significantly differ between benign and malignant tumors.

In our study, there was also a statistically significant relation between histopathological nature and comorbid diabetes and COPD. **Husebø *et al.*** [17] reported COPD as a risk factor for lung cancer, with proposed mechanisms including retention of carcinogens, oncogene activation, tumor suppressor gene suppression, chronic airway inflammation, involvement of distal airway stem cells, and shared genetic factors. Interestingly, all diabetic patients in this study had malignant lesions ($p<0.05$). This aligns with **Leiter *et al.*** [18] who linked diabetes with increased cancer risk through chronic inflammation, hyperinsulinemia, and immune modulation.

Radiologically, upper lobe involvement was predominant (50%), with right-sided lesions being more common than left (56.7% vs 36.7%). This pattern is consistent with **Nilssen *et al.*** [19] and may reflect anatomical and volumetric differences between lungs. CT was superior to chest X-ray, detecting masses in 55% of cases along with consolidation (28.3%), collapse (11.7%), and lymphadenopathy (10%). This aligns with **Rampinelli *et al.*** [20]**, with Elhefny *et al.*** [21] **and Fouda *et al.*** [8] who found lung masses in 40% and 52.5% of cases, respectively.

Histopathology revealed malignancy in 75% of cases (n=45), with 25% benign (n=15), a higher malignancy yield than typical bronchoscopy series, likely reflecting high pre-test probability. **Lam *et al.*** [22]**, Divisi *et al.*** [23] **and Abdelhady *et al.*** [24] reported

malignancy rates of 65%, 86%, and 50%, respectively, when using fluorescence bronchoscopy.

In anatomical site analysis, all visible endobronchial tumors (n=21) were correctly identified as grade 4 by both WLB and I-scan, correlating 100% with malignancy. I-scan upgraded 40% of grade 2 lesions to grade 3 compared to WLB, highlighting its advantage in detecting subtle abnormalities.

Squamous cell carcinoma was the most common type (26.7%), followed by adenocarcinoma (25%) and small cell carcinoma (16.7%). This is consistent with **Bodh *et al.* [25], Abdelhady *et al.* [24], and Biciuşcă *et al.* [26],** but differs from **Fouda *et al.* [13], Elhidsi *et al.* [27] and Tawfik *et al.* [12]** who found adenocarcinoma more common. The difference may be due to smoking prevalence, tumor location, and demographic patterns.

When comparing diagnostic performance, I-scan showed higher sensitivity for malignant lesions at grades 3 and 4 (73.3% vs 64.4%) with equal specificity (86.7%), and for non-endobronchial malignant lesions at grade 3 (76% vs 36%), though specificity favored WLB (92.9% vs 78.6%). These results are in line with **Abdelhady *et al.* [24], Fouda *et al.* [8] and Koraa *et al.* [28]**. Other modalities like autofluorescence bronchoscopy and narrow band imaging have shown variable sensitivities and specificities, as reported by **Herth *et al.* [29], Zaric *et al.* [30], Wang *et al.* [31], Zhu *et al.* [32] and Advani *et al.* [33].**

In our series, WLB had PPV, NPV, and accuracy of 93.6%, 44.8%, and 70%, respectively, while I-scan had 64.7%, 90.7%, and 83.3%. The significant NPV improvement with I-scan reduces unnecessary repeat procedures. **Advani *et al.* [33] and Wang *et al.* [31]** reported similar advantages in NPV with advanced imaging techniques.

Complications were acceptable: bleeding (38.3%), hypoxemia (23.3%), hypotension (6.7%), with no pneumothorax or cardiac arrest. **Fouda *et al.* [8] and Abdelhady *et al.* [24]** reported comparable safety profiles.

I-scan proves particularly valuable for subtle mucosal abnormalities and early lesions, with potential for targeted biopsies in high-risk patients. Limitations include small sample size, single-center design, and high malignancy prevalence. Larger, multi-center studies are recommended. Emerging technologies like robotic bronchoscopy, electromagnetic navigation, AI-assisted imaging, and molecular-guided "optical biopsies" may further enhance diagnostic precision [34].

CONCLUSION

I-scan bronchoscopy offers a superior diagnostic yield in suspect cases of lung cancer, particularly for non-endobronchial lesions, making it a valuable tool for early detection and diagnosis. Given its feasibility and relatively low cost compared to other advanced modalities, I-scan bronchoscopy has the potential to improve patient outcomes and enhance lung cancer diagnosis in a cost-effective manner.

No funding.

No conflict of interest.

REFERENCES

1. **World Health Organization (2022)**: Cancer fact sheet. Geneva: World Health Organization. https://www.paho.org/en/end-cervical-cancer
2. **Aravena C, Mehta A, Almeida F *et al.* (2023):** Innovation in rigid bronchoscopy—past, present, and future. J Thorac Dis., 15(5):2836–2847.
3. **Aljarod T, Alassal M, Alharthi A *et al.* (2025)**: Utility of EBUS-TBNA in evaluating mediastinal and hilar lymphadenopathy in routine practice. J Bronchol Interv Pulmonol., 32 (3):123–130.
4. **El-Bayoumi E, Silvestri G (2006)**: Bronchoscopy for the diagnosis and staging of lung cancer. Semin Respir Crit Care Med., 29(3): 261–270.
5. **Barlési F, Doddoli C, Greillier L *et al.* (2006)**: Bronchoscopy in the diagnosis of lung cancer: an evaluation of current practice. Rev Mal Respir., 23(2): 17-26.
6. **Bourne M, Norton M, Midthun D *et al.* (2021)**: Utility of transbronchial biopsy in the immunocompromised host with new pulmonary radiographic abnormalities. Mayo Clin Proc., 96:1500–1509.
7. **Van der Heijden E, Candoli P, Vasilev I *et al.* (2018)**: Image enhancement technology in bronchoscopy: a prospective multicentre study in lung cancer. BMJ Open Respir Res., 5:e000295. doi: 10.1136/bmjresp-2018-000295
8. **Fouda A, Ali R, Abdelmaksoud A *et al.* (2020)**: Role of HD i-scan bronchoscopy in the diagnosis of nonendobronchial lung cancer. Egypt J Chest Dis Tuberc., 69(4):664–670.
9. **Li C, Wang H, Jiang Y *et al.* (2022)**: Advances in lung cancer screening and early detection. Cancer Biol Med., 19:229–244.
10. **Andolfi M, Potenza R, Capozzi R *et al.* (2016)**: The role of bronchoscopy in the diagnosis of early lung cancer: a review. J Thorac Dis., 8:3329–3337.
11. **Fu Z, Jin Z, Zhang C *et al.* (2021)**: The future of endoscopic navigation: a review of advanced endoscopic vision technology. IEEE Access, 9:41144–41167.
12. **Tawfik S, Omar M, Nasr M *et al.* (2022)**: Role of advanced MRI in differentiation between benign and malignant lung lesions. Benha J Appl Sci., 7:47–55.
13. **Davis J, Chia S, Joubert A *et al.* (2010)**: Clinical features of lung cancer in patients presenting to an Australian regional hospital. Aust J Rural Health, 18:225–229.
14. **Moore E, Palmer T, Titley J *et al.* (2011)**: Symptoms and presentation of lung cancer in primary care: a prospective case-control study. Br J Gen Pract., 61:347–354.
15. **Vesel C, Nannini N, Chetty A *et al.* (2021)**: Lung cancer symptom appraisal and help-seeking in South Africa: a qualitative study. BMJ Open, 11:e044832. doi: 10.1002/pon. e044832.

16. **Vincent B, Fraig M, Silvestri G (2007)**: Narrow-band imaging compared to white light bronchoscopy for evaluation of airways. Chest, 131:1794–1799.
17. **Husebø G, Nielsen R, Hardie J *et al.* (2019)**: Risk factors for lung cancer in COPD - results from the Bergen COPD cohort study. Respir Med., 152:81-88.
18. **Leiter A, Afzal S, Henriksson A *et al.* (2021)**: Diabetes and the risk of lung cancer: a prospective cohort study. Diabetologia, 64:1825–1835.
19. **Nilssen Y, Brustugun O, Fjellbirkeland L *et al.* (2024)**: Distribution and characteristics of malignant lung tumours by lobe. BMC Pulm Med., 24:106. doi: 10.1186/s12890-024-02918-w.
20. **Rampinelli C, De Marco P, Origgi D *et al.* (2016)**: Exposure to low dose computed tomography for lung cancer screening and risk of cancer: secondary analysis of trial data and risk-benefit analysis. BMJ., 355:i5950. doi: 10.1136/bmj.j347.
21. **Elhefny R, Elessawy A, Abou-Beih S *et al.* (2016)**: Comparison of narrow band imaging to white light bronchoscopy for evaluation of histopathological biopsy. Egypt J Chest Dis Tuberc., 65:341–347.
22. **Lam S, MacAulay C, leRiche J *et al.* (2000)**: Detection and localization of early lung cancer by fluorescence bronchoscopy. Cancer, 89:2468–2473.
23. **Divisi D, Di Tommaso S, De Vico A *et al.* (2010)**: Early diagnosis of lung cancer using a SAFE-3000 autofluorescence bronchoscopy. Interact Cardiovasc Thorac Surg., 11:740–744.
24. **Abdelhady A, Abdallah D, Elnady M *et al.* (2020)**: Role of I-scan technique in screening for lung cancer in smokers with positive sputum cytology. Egypt J Bronchol., 14: 2-6.
25. **Bodh A, Kaushal V, Kashyap S *et al.* (2013)**: Clinicopathological profile of lung cancer in Himachal Pradesh, India: a 3-year study. Indian J Chest Dis Allied Sci., 55:145–148.
26. **Biciuşcă V, Iliescu D, Rusu E *et al.* (2022)**: Histopathological features of lung cancer: correlations with smoking and other risk factors. Rom J Morphol Embryol., 63:471–478.
27. **Elhidsi M, Harahap I, Yunus F *et al.* (2024)**: Characteristics of primary central lung tumors at Persahabatan Hospital, Jakarta. J Thorac Oncol., 19:279–280.
28. **Koraa E, El-Assal G, Farghaly A *et al.* (2024)**: Role of confocal laser endomicroscopy compared with high definition i-scan video bronchoscopy in patients with suspected lung cancer. Egypt J Chest Dis Tuberc., 73:120–125.
29. **Herth F, Eberhardt R, Anantham D *et al.* (2009)**: Narrow-band imaging bronchoscopy increases the specificity of bronchoscopic early lung cancer detection. J Thorac Oncol., 4:1060–1065.
30. **Zaric B, Perin B, Stojsic V *et al.* (2013)**: Detection of premalignant bronchial lesions can be significantly improved by combination of advanced bronchoscopic imaging techniques. Ann Thorac Med., 8:93–98.
31. **Wang G, Jin Y, Xiong K *et al.* (2024)**: Utility of autofluorescence-guided biopsy in suspected lung cancer patients with bronchial mucosal lesions. Photodiagn Photodyn Ther., 46:104057. doi: 10.1016/j.pdpdt.2024.104057.
32. **Zhu J, Li W, Zhou J *et al.* (2017)**: The diagnostic value of narrow-band imaging for early and invasive lung cancer: a meta-analysis. Clinics, 72:438–448.
33. **Advani M, Purohit G, Vyas S *et al.* (2018)**: Comparison of diagnostic potential of narrow band imaging bronchoscopy over white light bronchoscopy in lung cancer. J Bronchol Interv Pulmonol., 25:132–136.
34. **Agrawal A, Chhajed P, Dhand R *et al.* (2023)**: Emerging technologies in bronchoscopy: the future of lung cancer diagnosis and therapy. Lung India, 40:201–209.