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Diagnostic yield of fiber optic bronchoscopy, fine needle aspiration cytology of lung, spontaneous sputum cytology, and induced sputum cytology in suspected cases of bronchogenic carcinoma

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Abstract

Background: Bronchogenic carcinoma remains a major cause of cancer-related morbidity and mortality, and early diagnosis relies on the effective use of clinical, radiological, and cytological diagnostic modalities. Evaluating the diagnostic yield of commonly employed invasive and non-invasive techniques is essential for optimizing diagnostic strategies.

Methods: This retrospective observational study was conducted in the Department of Respiratory Medicine at PGIMER and Capital Hospital, Bhubaneswar. A total of 120 patients with suspected bronchogenic carcinoma admitted between March 2024 and September 2025 were evaluated. Eighty-two cases were confirmed as bronchogenic carcinoma and included for analysis. All patients underwent detailed clinical evaluation and radiological assessment. Diagnostic procedures included fiber optic bronchoscopy with multiple sampling techniques, CT-guided fine needle aspiration cytology (FNAC), spontaneous sputum cytology using three early-morning samples, and induced sputum cytology using hypertonic saline nebulization. Diagnostic yields of these modalities were analyzed and compared.

Results: The study population showed a marked male predominance, with the highest incidence in the 51–60-year age group. Fiber optic bronchoscopy demonstrated the highest diagnostic yield (46.66%), followed closely by CT-guided FNAC (44.44%). Induced sputum cytology showed a moderate diagnostic yield (24.39%), while spontaneous sputum cytology had a low diagnostic yield (7.69%). Radiologically, mass lesions were the most common finding. Adenocarcinoma was the most frequent histological subtype.

Conclusion: Fiber optic bronchoscopy and CT-guided FNAC remain the most effective diagnostic modalities for bronchogenic carcinoma. Induced sputum cytology serves as a useful non-invasive adjunct, whereas spontaneous sputum cytology alone has limited diagnostic value. A multimodal, stepwise diagnostic approach is essential for timely and accurate diagnosis, particularly in tertiary care settings.

Keywords: Bronchogenic Carcinoma, Fiber Optic

Bronchoscopy, FNAC, Sputum Cytology, Induced Sputum, Diagnostic Yield, Lung Cancer

Introduction

Lung cancer accounts for a substantial share of global cancer mortality, making timely and accurate diagnosis essential for improving outcomes. Globally, it stands as one of the most common cancers and the leading cause of cancer-related deaths in both men and women, posing a significant public health burden.[1] The overwhelming majority of lung cancer cases are attributable to tobacco smoking, which is implicated in approximately 80-90% of diagnoses. Beyond active smoking, other critical risk factors include exposure to secondhand smoke, occupational hazards such as asbestos, radon, arsenic, chromium, and nickel, air pollution, genetic predispositions, and a history of certain chronic lung diseases. These diverse etiological factors underscore the complex nature of bronchogenic carcinoma and highlight the urgent need for effective screening and early detection strategies.[2]

Early diagnosis and timely intervention are crucial for minimizing mortality and improving the 5-year survival rate for bronchogenic carcinoma.[1] Current surgical treatment options for lung cancer are primarily offered for stages at or below IIIA-TNM, underscoring the critical role of early detection in reducing cancer-related mortality[2]. Despite advances in imaging and therapeutic modalities, lung tumors often present as masses or nodules beyond the reach of conventional fiberoptic bronchoscopes, necessitating improved diagnostic techniques[3]. This challenge is further complicated by the fact that many lung cancers are diagnosed at an advanced stage, making early detection paramount to reducing mortality rates [4,5]. The intricate and protracted nature of lung cancer diagnosis frequently delays effective treatment, thereby negatively impacting clinical outcomes[6]. In India, for instance, nearly 50% of lung cancer patients present with distant metastasis, contributing to persistently low five-year survival rates [7]. This alarming statistic underscores the urgent need for enhanced diagnostic algorithms and modalities to facilitate earlier detection and intervention, particularly in regions with high disease burden [8].

To address these diagnostic challenges, several modalities are employed. Fiber optic bronchoscopy enables direct visualization and sampling of central airways and frequently achieves high yields when endobronchial disease is present, particularly with combined forceps biopsy, brushings, and washings. CT-guided fine needle aspiration cytology provides a minimally invasive route to sample peripheral parenchymal lesions that may be beyond bronchoscopic reach, with reported high accuracy when performed under imaging guidance. Sputum cytology offers a non-invasive option; however, sensitivity varies by lesion size and location, with spontaneous sputum generally less sensitive than induced sputum collected after hypertonic saline inhalation. Standardizing how these modalities are integrated, based on anatomy, imaging features, and patient factors can improve diagnostic efficiency and reduce time to treatment. This study/template aims to compare the diagnostic yield of FOB, CT-guided FNAC, spontaneous sputum cytology, and induced sputum cytology in suspected bronchogenic carcinoma, and to outline a pragmatic workflow for resource-constrained settings

Materials and Methods

Study Design and Setting

This retrospective observational study was conducted in the Department of Respiratory Medicine at PGIMER and Capital Hospital, Bhubaneswar. A total of 120 patients with clinical and radiological suspicion of bronchogenic

carcinoma, admitted to the Chest Ward between March 2024 and September 2025, were included in the study.

Clinical Evaluation

All patients underwent a detailed clinical evaluation, including comprehensive history taking, physical examination, and relevant laboratory and radiological investigations, as documented in a predefined proforma (Appendix I).

Fiber Optic Bronchoscopy

Fiber optic bronchoscopy (FOB) was performed in indicated cases with systematic inspection of the tracheobronchial tree. Sampling techniques included forceps biopsy for visible endobronchial lesions, bronchial brushings, bronchial washings, bronchoalveolar lavage, and transbronchial needle aspiration where clinically indicated.

CT-Guided Fine Needle Aspiration Cytology

CT-guided fine needle aspiration cytology (FNAC) was performed for peripheral or mediastinal lung lesions using percutaneous aspiration techniques under imaging guidance. Cytological smears were prepared using standard staining protocols. Rapid on-site adequacy assessment was performed where feasible.

Sputum Cytology

Spontaneous sputum cytology was carried out using three early-morning sputum samples collected on consecutive days. In patients unable to expectorate adequate sputum spontaneously, induced sputum cytology was performed using hypertonic saline (3–5%) nebulization following a standardized protocol.

Ethical Statement

The present retrospective observational study was conducted in accordance with the ethical principles outlined in the Declaration of Helsinki. Approval for the study was obtained from the Institutional Ethics Committee of PGIMER and Capital Hospital, Bhubaneswar. As the study involved retrospective analysis of existing clinical and radiological data with no direct patient contact or intervention, the requirement for informed consent was waived by the Ethics Committee. Patient confidentiality and anonymity were strictly maintained throughout the study, and all data were anonymized prior to analysis.

Results

A total of 120 patients with suspected bronchogenic carcinoma were evaluated during the study period, of whom 82 cases were confirmed as bronchogenic carcinoma and included for final analysis.

Demographic Profile

The age and sex distribution of the 82 diagnosed cases is shown in figure 1. The study population demonstrated a marked male predominance, with 68 males (82.92%) and 14 females (17.08%). No cases were observed below 30 years of age. The highest incidence was noted in the 51–60-year age group (29.26%), followed by patients aged above 60 years (24.39%).

Clinical Presentation

The spectrum of presenting symptoms is summarized in Table 1. Cough was the most common symptom, reported in 68 patients (82.92%), followed by fever in 44 cases (53.68%) and chest pain in 38 cases (46.34%). Haemoptysis was observed in 30 patients (36.58%). Features suggestive of advanced disease, such as superior vena caval syndrome and Pancoast syndrome, were each noted in 6 patients (7.32%).

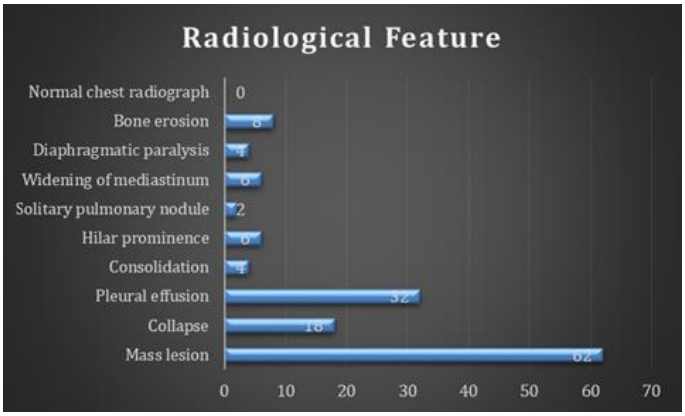
Physical Findings

Physical examination findings are detailed in Table 2. Pallor (73.17%) and digital clubbing (70.73%) were the most frequent clinical signs. Lymphadenopathy was present in 42 patients (51.22%). Clinical indicators of locally advanced or metastatic disease, including superior

vena caval syndrome, Pancoast syndrome, and vocal cord paralysis, were observed in a smaller proportion of cases.

Radiological Findings

Radiological features observed in patients with bronchogenic carcinoma are presented in figure 2. A mass lesion was the most common radiological finding, seen in 62 cases (75.60%). Pleural effusion was present in 32 cases (39.02%), while lung collapse was observed in 18 cases (21.95%). None of the patients had a normal chest radiograph at presentation.



Sputum Production

Spontaneous sputum production among the study participants is shown in Table 3. Sputum production was present in 116 out of 120 patients (96.67%). Among the 82 confirmed cases of bronchogenic carcinoma, 78 patients produced sputum spontaneously, while 4 patients did not.

Diagnostic Yield of Spontaneous Sputum Cytology

The diagnostic yield of spontaneously produced sputum cytology using three early-morning samples collected on consecutive days is depicted in Table 4. The cumulative diagnostic yield increased with repeated sampling but remained low, reaching 7.69% after the third sample.

Diagnostic Yield of Induced Sputum Cytology

The results of induced sputum cytology using hypertonic saline (3–5%) nebulization are shown in Table 5. Induced sputum cytology demonstrated a higher diagnostic yield compared to spontaneous sputum, with a cumulative positivity of 24.39% after three samples.

Overall Diagnostic Yield of Sputum Cytology

The combined diagnostic yield of sputum cytology techniques is summarized in Table 6. Sputum cytology established a diagnosis in 22 cases (26.83%). Of these, 16 cases (19.51%) were diagnosed exclusively by induced sputum cytology, while only 2 cases (2.44%) were diagnosed solely by spontaneous sputum cytology.

Diagnostic Yield of CT-Guided FNAC

The diagnostic yield of CT-guided fine needle aspiration cytology is presented in figure 3. FNAC was performed in 54 cases of bronchogenic carcinoma, yielding a definitive cytological diagnosis in 24 cases (44.44%). The overall diagnostic yield of FNAC across all evaluated cases was 45.55%.

Diagnostic Yield of Fiber Optic Bronchoscopy

The diagnostic yield of fiber optic bronchoscopy is shown in figure 4. Among 30 cases of bronchogenic carcinoma undergoing bronchoscopy, direct cytological evidence was obtained in 6 cases, while indirect evidence was noted in 8 cases, resulting in an overall diagnostic yield of 46.66%.

Comparative Diagnostic Yield

A comparison of the diagnostic yields of various procedures is summarized in Figure 5. Fiber optic bronchoscopy demonstrated the highest diagnostic yield (46.66%), followed closely by CT-guided FNAC (44.44%). Induced sputum cytology showed a moderate diagnostic yield (24.39%), whereas spontaneous sputum cytology had the lowest yield (7.69%).

Discussion

Bronchogenic carcinoma remains one of the leading causes of cancer-related morbidity and mortality worldwide, and timely diagnosis depends on the optimal use of clinical, radiological, and cytological diagnostic

modalities. The present study evaluated and compared the diagnostic yield of fiber optic bronchoscopy, CT-guided fine needle aspiration cytology, and sputum cytology techniques in suspected cases of bronchogenic carcinoma. Gupta et al. have reported that bronchogenic carcinoma predominantly affects males in the fifth and sixth decades of life, reflecting higher exposure to tobacco smoke and occupational carcinogens.[9] The present study demonstrated a similar demographic pattern, with a marked male predominance (82.92%) and peak incidence in the 51–60-year age group, supporting the well-established epidemiological trends of lung cancer in the Indian population. According to Sharma et al. observed that cough, chest pain, and haemoptysis constitute the most frequent presenting symptoms in patients with bronchogenic carcinoma, while systemic symptoms often indicate advanced disease. In concordance with these findings, cough was the most common symptom in the present study (82.92%), followed by fever and chest pain. Haemoptysis was noted in over one-third of patients, highlighting its continued relevance as a warning symptom of lung malignancy[10].

Physical findings such as pallor, digital clubbing, and lymphadenopathy are common in bronchogenic carcinoma and often correlate with disease burden are reported in Mohan et al. Similar observations were made in the present study, where pallor and clubbing were the predominant clinical signs, and lymphadenopathy was present in more than half of the cases, suggesting advanced or metastatic disease at presentation in a significant proportion of patients.[11] Emphasized that chest radiography remains a sensitive initial investigation in suspected lung cancer, with mass lesions being the most frequent abnormality in Mukherjee et al.. The present study corroborates these findings, as a mass lesion was the most common radiological feature (75.60%), and no patient had a normal chest radiograph, underscoring the diagnostic value of imaging in initial evaluation.[12]

Chowdhury et al. demonstrated that spontaneous sputum cytology has a low diagnostic yield in lung cancer, particularly when used as a standalone diagnostic tool. In agreement with their findings, the present study showed a low cumulative diagnostic yield of spontaneous sputum cytology (7.69%) despite examination of three consecutive early-morning samples, reinforcing its limited sensitivity [13]. Similarly, in Thompson et al. highlighted that induced sputum cytology improves diagnostic yield compared to spontaneous sputum by enhancing exfoliation of malignant cells[14]. The present study supports this observation, as induced sputum cytology using hypertonic saline nebulization achieved a substantially higher cumulative diagnostic yield (24.39%). Although inferior to invasive techniques, induced sputum cytology proved to be a useful non-invasive adjunct, especially in patients unsuitable for invasive procedures.

Gupta et al. and Rajwanshi et al. reported that CT-guided FNAC is a highly effective diagnostic modality for peripheral lung lesions, with diagnostic yields ranging between 40% and 90% depending on lesion characteristics and operator expertise.[9,15] In the present study, CT-guided FNAC yielded a definitive diagnosis in 44.44% of bronchogenic carcinoma cases, which is comparable to yields reported in similar tertiary-care settings and highlights its value in the diagnostic algorithm.

Biswas et al. emphasized that fiber optic bronchoscopy offers optimal diagnostic yield when multiple sampling techniques are employed rather than biopsy alone.[16] The present study demonstrated the highest diagnostic yield with fiber optic bronchoscopy (46.66%), achieved through a combination of forceps biopsy, bronchial

brushings, washings, bronchoalveolar lavage, and transbronchial needle aspiration where indicated. These findings reaffirm the central role of bronchoscopy in diagnosing centrally located bronchogenic carcinoma. Rivera et al. proposed that a multimodal diagnostic approach tailored to lesion location yields the best diagnostic outcomes in lung cancer.[17] The comparative analysis in the present study supports this concept, as fiber optic bronchoscopy and CT-guided FNAC demonstrated the highest diagnostic yields, followed by induced sputum cytology, while spontaneous sputum cytology had the lowest yield.[18]

Overall, the findings of the present study are consistent with existing literature and demonstrate that while non-invasive sputum-based techniques have limited diagnostic utility, invasive procedures such as fiber optic bronchoscopy and CT-guided FNAC remain the cornerstone of definitive diagnosis in suspected bronchogenic carcinoma.

Conclusion

The findings of the present study demonstrate that invasive diagnostic modalities, particularly fiber optic bronchoscopy and CT-guided fine needle aspiration cytology, provide the highest diagnostic yield in suspected cases of bronchogenic carcinoma. Induced sputum cytology offers a useful non-invasive adjunct with a moderate diagnostic yield, whereas spontaneous sputum cytology alone has limited diagnostic utility. A stepwise, multimodal diagnostic approach tailored to lesion location and patient suitability is essential for achieving timely and accurate diagnosis of bronchogenic carcinoma, especially in resource-limited tertiary care settings.

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Legend Figures and Tables

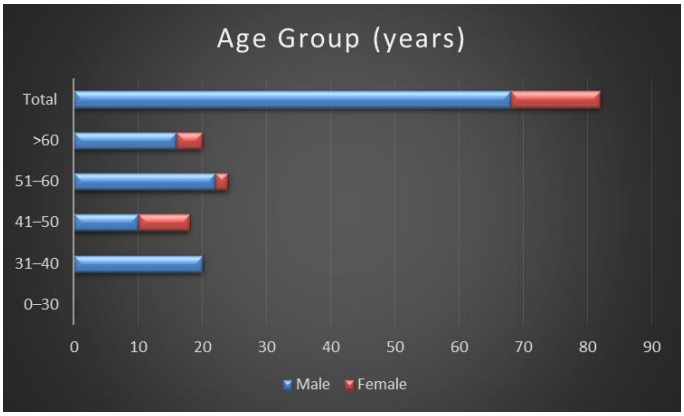

Figure 1: The age and sex distribution of the 82 diagnosed cases is shown in figure I. The study population demonstrated a marked male predominance, with 68 males (82.92%) and 14 females (17.08%).

Table 1: Clinical Presentation

Sn.	Symptom	Number of Cases	Percentage
1	Cough	68	82.92
2	Haemoptysis	30	36.58
3	Chest pain	38	46.34
4	Fever	44	53.68
5	Breathlessness	24	29.26
6	Loss of appetite	26	31.7
7	Loss of body weight	22	26.84
8	Hoarseness of voice	6	7.32

9	Dysphagia	2	2.44
10	Superior vena caval syndrome	6	7.32
11	Pancoast syndrome	6	7.32

Table 2: Physical Findings in 82 Cases of Bronchogenic Carcinoma

Sn.	Clinical Finding	Number of Cases	Percentage
1	Pallor	60	73.17
2	Clubbing	58	70.73
3	Osteoarthropathy	0	0
4	Fever	44	53.68
5	Dyspnoea	24	29.66
6	Gynaecomastia	4	4.88
7	Lymphadenopathy	42	51.22
8	Superior vena caval syndrome	6	7.32
9	Pancoast syndrome	6	7.32
10	Vocal cord paralysis	6	7.32
11	Subcutaneous nodules	2	2.44
12	Enlarged nodular liver	2	2.44

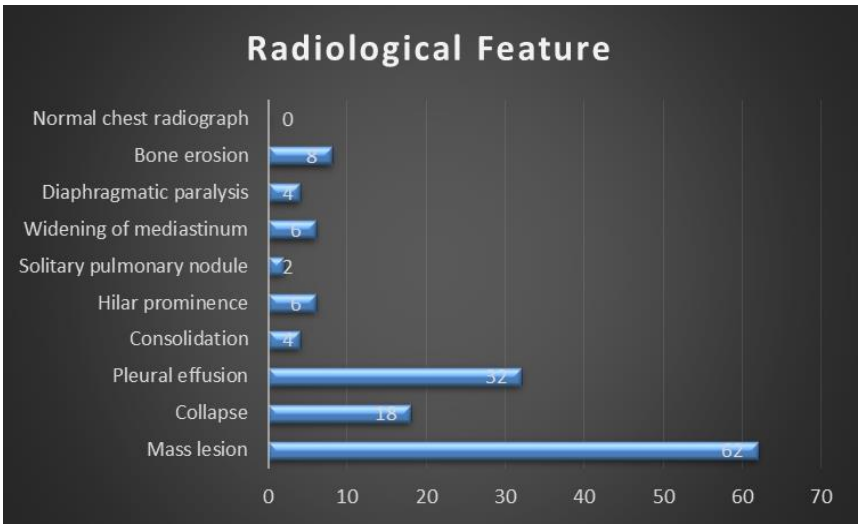

Figure 2: Radiological features observed in patients with bronchogenic carcinoma are presented in figure 2.

Table 3: Spontaneous Production of Sputum among Study Participants (n=120)

Sputum Production	Bronchogenic Carcinoma (n=82)	Other Diseases (n=38)	Total	Percentage
Present	78	38	116	96.67
Absent	4	0	4	3.33
Total	82	38	120	100.0

Table 4: Diagnostic Yield of Spontaneously Produced Sputum Cytology (Three Early-Morning Samples on Consecutive Days)

Sample	Samples Examined	Positive	Negative	Cumulative Positive	Cumulative %
1st	78	2	76	2	2.56
2nd	76	3	73	5	6.41
3rd	73	1	72	6	7.69

Table 5: Diagnostic Yield of Induced Sputum Cytology (Hypertonic Saline 3–5% Nebulization)

Sample	Samples Examined	Positive	Negative	Cumulative Positive	Cumulative %
1st	82	6	76	6	7.32
2nd	76	10	66	16	19.51
3rd	66	4	62	20	24.39

Table 6: Diagnostic Yield from Sputum Cytology in 82 Cases of Bronchogenic Carcinoma

Method	Malignant Cells Positive	Number of Cases	Percentage
Only spontaneously produced sputum cytology	Yes	2	2.44
Only heated aerosol induced sputum cytology	Yes	16	19.51
Both methods	Yes	4	4.88
Total diagnosed by sputum cytology	—	22	26.83

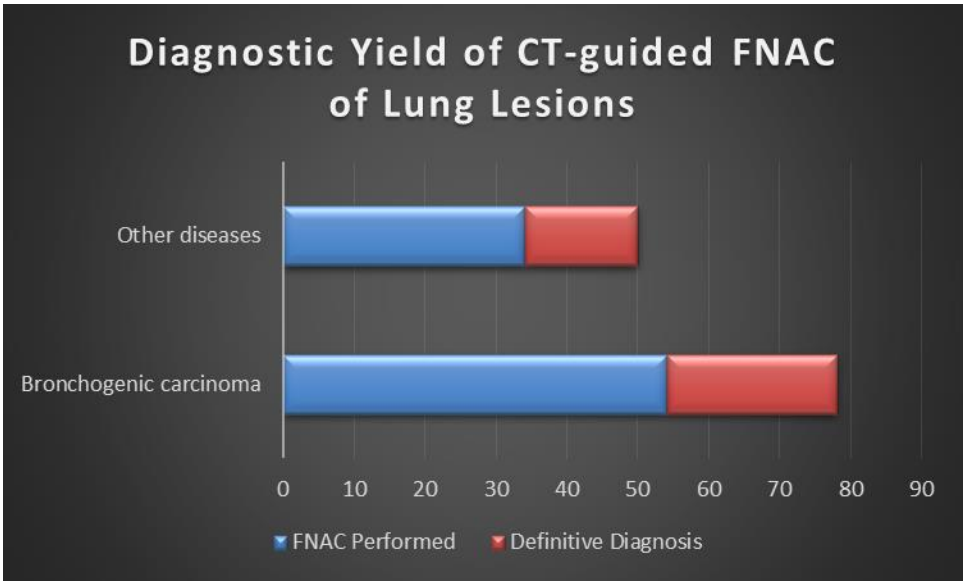

Figure 3: The diagnostic yield of CT-guided fine needle aspiration cytology is presented in figure 3.

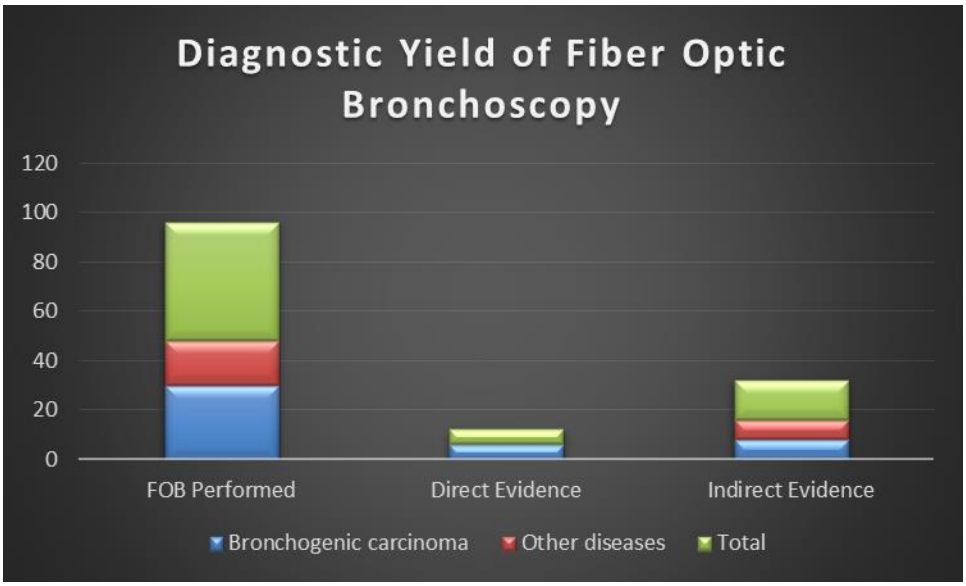

Figure 4: The diagnostic yield of fiber optic bronchoscopy is shown in figure 4.

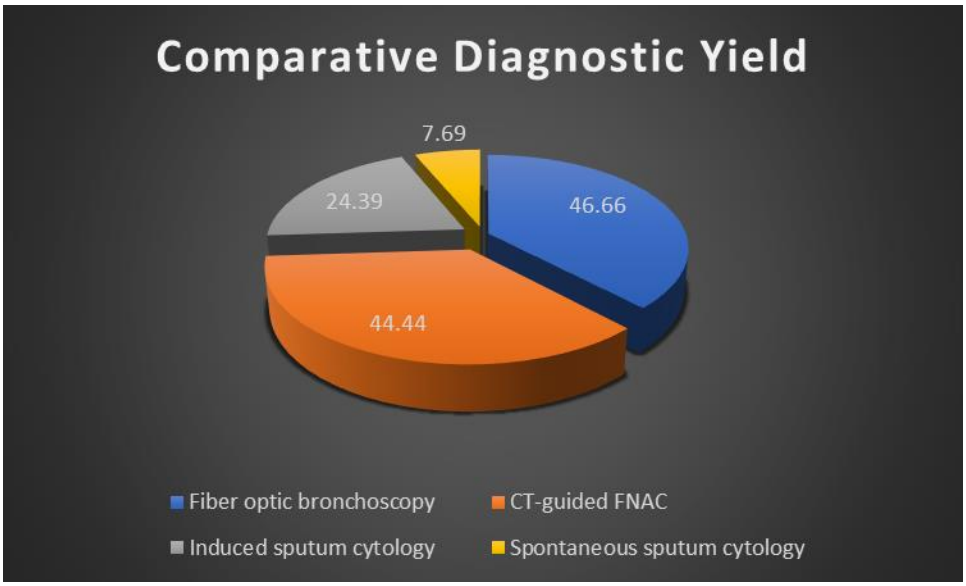

Figure 5: A comparison of the diagnostic yields of various diagnostic procedures