THE QUALITY OF PULMONARY DIAGNOSIS IN PATIENTS WITH LUNG CANCER QUALIFIED FOR THORACIC SURGERIES

Jakość diagnostyki pulmonologicznej u pacjentów z guzem płuca kwalifikowanych do procedur torakochirurgicznych

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Abstract

Introduction and objective: Lung cancer is diagnosed in most cases at a late stage. Primary diagnosis of patients takes place in pulmonology departments. More effective primary diagnosis through cooperation with thoracic surgery and oncology departments appears to be the key to better treatment outcomes. **Objective:** The aim of this article was to assess the value of diagnosis performed in the Department of Pulmonology in terms of determining the aetiology and stage of lung cancer and qualifying for thoracic surgical diagnostic and therapeutic procedures. **Materials and methods:** The study included 51 patients with lung cancer detected in imaging tests, who, following a series of diagnostic tests performed in the Department of Pulmonology, e.g. bronchofiberoscopy, fine-needle aspiration biopsy, cytology of the pleural fluid, spirometry, diffusing capacity of the lungs for carbon monoxide, and laboratory tests, were referred to the Department of Thoracic Surgery for radical treatment or complementary invasive diagnosis. **Results:** The efficacy of pulmonological diagnostic tests in detecting malignancies in the study group was found to be relatively high, with sensitivity of 0.66, specificity of 0.81, and accuracy of 0.71. As a result, radical surgery could be performed in 24 patients (47.06%). Thoracic surgical diagnostic procedures allowed for total lung tumour resection in another 7 patients. In total, 31 patients underwent optimal lung resection(60.78%). **Conclusions:** Cooperation of the Department of Pulmonology with complementary thoracic surgical diagnostic tests allows for precise determination of the aetiology of lung cancer and implementing therapeutic surgeries in technically resectable cancers.

Streszczenie

Wprowadzenie i cel: Rak płuca w większości przypadków jest rozpoznawany w późnym stadium choroby. Wstępna diagnostyka pacjentów odbywa się na oddziałach o profilu pulmonologicznym. Poprawa jej skuteczności i współpraca z torakochirurgami oraz onkologami wydaje się być kluczem do poprawy wyników leczenia. Celem artykułu jest ocena wartości diagnostyki przeprowadzonej na oddziale pulmonologicznym w aspekcie ustalenia etiologii i zaawansowania guza płuca oraz kwalifikacji do torakochirurgicznych procedur diagnostycznych i leczniczych. **Materiał i metody:** Oceną objęto 51 pacjentów z guzem płuca wykrytym w badaniach obrazowych, którzy po wykonaniu na oddziale pulmonologii badań diagnostycznych obejmujących bronchofiberoskopię, biopsję transtorakalną, badanie cytologiczne płynu z opłucnej, spirometrię, badanie zdolności dyfuzyjnej płuc dla tlenku węgla i badania laboratoryjne zostali skierowanych na oddział torakochirurgii w celu przeprowadzenia leczenia radykalnego lub uzupełniającej diagnostyki inwazyjnej. **Wyniki:** Jakość diagnostyki pulmonologicznej w wykrywaniu nowotworu złośliwego w badanej grupie okazała się stosunkowo wysoka (czułość: 0,66, swoistość: 0,81, dokładność: 0,71). Dzięki temu u 24 pacjentów (47,06%) możliwe było wykonanie operacji radykalnej. Po uwzględnieniu diagnostycznych procedur torakochirurgicznych doszczętne usunięcie guza płuca wykonano u kolejnych 7 chorych. Łącznie u 31 pacjentów przeprowadzono optymalne zabiegi resekcyjne płuca (60,78%). **Wnioski:** Współpraca oddziału pulmonologii w połączeniu z uzupełniającą diagnostyką torakochirurgiczną pozwala na dokładne ustalenie etiologii guza płuca oraz wykonanie operacji terapeutycznych w nowotworach technicznie resekcyjnych.

Keywords: lung cancer; bronchofiberoscopy; VATS; fine needle aspiration biopsy

Słowa kluczowe: rak płuca; bronchofiberoskopia; VATS; biopsja aspiracyjna cienkoigłowa

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Introduction

Primary lung cancer (PLC) is the second most common malignancy worldwide (2.2 million cases in 2020) [1]. However, it is responsible for the highest rates of cancer mortality in both women and men (approximately 18%), with a 5-year survival rate of 7–25%, which is lower than for many other cancers [2].

PLC is initially clinically asymptomatic, with no concerns raised until symptoms appear in the late stage of disease, when the tumour causes narrowing of large bronchi, affects mediastinal structures, or when distant metastases appear and it is too late for surgical intervention. Almost 46.6% of patients have clinical stage IV at diagnosis, and interestingly, almost 50% of them present only one or two symptoms [3]. The most optimal therapeutic outcomes are achieved at an early stage of the disease. In the case of non-small cell lung cancer (NSCLC), radical resection of the tumour along with regional lymph nodes is considered most effective, which is possible at stages I, II and IIIA [4, 5].

Naturally, efforts are made to improve the diagnostic efficacy through early detection, as well as PLC grading and staging in order to select the optimal treatment approach.

Initial diagnosis in LC patients is usually performed in pulmonology departments. Imaging modalities, such as computed tomography (CT) [6] and less accessible positron emission tomography (PET) [7, 8], allow to determine the size and location of the tumour, the presence of hilar and mediastinal lymphadenopathy, and distant metastases. Routine diagnostic tests used to determine the aetiology of the tumour include bronchofiberoscopy (FOB) with histopathological specimen collection [9, 10], endobronchial ultrasound-guided transbronchial biopsy of the mediastinal nodes or the tumour itself (EBUS-TBNA) [11]. In patients with peripheral tumours, cytological diagnosis can be obtained with transthoracic fine needle aspiration biopsy (FNAB) [12] or core needle biopsy [13]. Pulmonary function tests (PFTs) using spirometry, scintigraphy and diffusing capacity of the lungs for carbon monoxide (DLCO) [14], as well as a history of comorbidities are important elements of complementary pulmonary diagnosis. Patients with less advanced tumours, who are in good general condition and meet the appropriate respiratory function criteria are qualified for surgical treatment. In some patients, pulmonary diagnosis does not allow determining the aetiology of the tumour. Such patients are usually referred for further diagnosis in the Department of Thoracic Surgery, where it is possible to perform minimally invasive procedures, such as mediastinoscopy [15], core needle biopsy, Daniels biopsy [16], and video-assisted thoracoscopic surgery (VATS), which, apart from its diagnostic role, may in some cases allow for simultaneous radical resection of the tumour [17, 18].

Current model of diagnostic and therapeutic management in the Department of Pulmonology

A specialist from the Department of Pulmonology of the Provincial Health Care Centre For The Treatment Of Lung Diseases And Rehabilitation in Łódź consults patients who are referred to the hospital from three sources: primary care clinics, specialist lung disease clinics and other hospital centres. At this stage, decisions are made about both further diagnostic path and qualification for invasive diagnostic procedures in the Department of Pulmonology. Patients with comorbidities often additionally require appropriate treatment or modification of their current therapy. After an individual assessment of cardiovascular (CV) risk in an LC patient, based on medical history and electrocardiography, PFTs are performed for ventilatory disorders. Imaging modalities are also done as a standard unless they had been performed earlier. CT is of particular importance. Additionally, abdominal ultrasound (US) is performed if necessary, and if the presence of pleural fluid is suspected, chest US with pleural puncture (thoracentesis) is done, with the evacuated fluid sent for general, bacteriological and cytological analyses. The next diagnostic step at the Department of Pulmonology is to perform invasive investigations, such as bronchofiberoscopy (FOB) and percutaneous FNAB of the lung tumour. Patients who require improvement of their clinical condition receive individualised optimal treatment. Then, patients who qualify for surgery or require more in-depth diagnosis are consulted by a thoracic surgeon from a cooperating centre from the Department of Thoracic Surgery, General and Oncological Surgery of the University Clinical Hospital of the Military Medical Academy.

Aims

- Evaluation of selected clinical parameters, as well as cytological and histopathological diagnosis in patients with LC detected in imaging during hospital stay in the Department of Pulmonology.
- Assessment of the quality of the diagnostic process conducted at the Department of Pulmonology in terms of determining the aetiology and stage of LC.
- Evaluation of the efficacy of combined pulmonary and thoracic surgery diagnosis in the qualification of LC patients for optimal treatment.

Materials and methods

The study group consisted of 74 patients initially diagnosed in the Department of Pulmonology due to radiological suspicion of LC. Men and women accounted for

54.1% (*n* = 40, age 44–75 years) and 45.9% (*n* = 34, age 26–76 years) of the study group, respectively. All patients underwent diagnostic procedures including FOB, FNAB, cytology of pleural fluid and complementary investigations, including spirometry, laboratory workup, DLCO (some patients), etc.

After completing pulmonary diagnosis, a thoracic surgery consultation was done. Patients with an established histopathological diagnosis of NSCLC and a specific staging based on the TNM classification were referred for radical surgery. The remaining patients with cancer of unspecified aetiology were qualified for complementary invasive thoracic surgery diagnosis. Ultimately, 51 patients, who were referred for radical treatment or invasive diagnostic procedures at the Department of Thoracic Surgery following pulmonological diagnosis, were qualified for statistical analysis, which enabled a comparison of the efficacy of cytological and histopathological tests from both centres.

Statistical analysis

Statistical calculations were performed using Statistica ver. 12 (StatSoft, USA) and Excel. The Shapiro-Wilk W test was used to verify whether the quantitative variable came from a population with a normal distribution. The Leven's (Brown-Forsythe) test was used to verify the hypothesis of equal variances. The significance of differences between two groups (model of unrelated variables) was assessed using the Student's t-test (or the Welch test in the case of lack of homogeneity of variances) or the Mann-Whitney U test (if the conditions of applicability of the Student's t-test were not met or for variables measured on an ordinal scale).

In the case of statistically significant differences between groups, post hoc tests were used (Tukey's test for F, Dunn's test for Kruskal-Wallis). Chi-square tests of independence were employed for qualitative variables (with Yates' correction for cell counts below 10, checking Cochran's conditions, Fisher's exact test, respectively). In order to determine the relationship, strength and direction between variables, correlation analysis was used, calculating Pearson's and/or Spearman's correlation coefficients. In all calculations, the level of significance was assumed at $p = 0.05$.

When evaluating the outcomes of diagnostic and therapeutic procedures used in the Department of Thoracic Surgery, statistical studies were conducted using the Statgraphics Centurion 18 ver. 18.1.12 (Statgraphics Technologies Inc., USA). Qualitative variables were tested using the Chi^2 test of independence (i.e. χ^2). The level of statistical significance was $p < 0.05$.

Quality assessment of pulmonological diagnostic procedures in LC

Diagnostic procedures in the Department of Pulmonology

The study group consisted of 51 patients with LC detected on imaging, including 28 women and 23 men. The age of patients ranged from 51 to 81 years (mean: 66.96 ± 7.95 years).

Diagnostic tests were run in the Department of Pulmonology to determine LC aetiology (fig. 1, tab. 1).

Imaging was performed in 98.6% of patients. No repeat CT was performed in patients with up-to-date outpatient results (not older than one month). The most important investigations were those used to collect tumour specimens for pathomorphological evaluation, including cytology and histopathology. Among these, endoscopic diagnostic procedures (mainly FOB) and transthoracic FNAB of the lung were performed in 71.6% and 56.8% of patients, respectively.

Other diagnostic modalities were used to assess patients' general condition, respiratory function and to identify comorbidities. Among these, spirometry assessment of pulmonary function, which was performed in 60.8% of patients, was the primary test. Assessment of the circulatory system was performed in 95.9% of patients. In the Department of Pulmonology, all patients (100%) underwent microbiological tests focused primarily on infections with non-specific and specific microbes (tuberculosis and non-tuberculosis mycobacteria). Seven patients

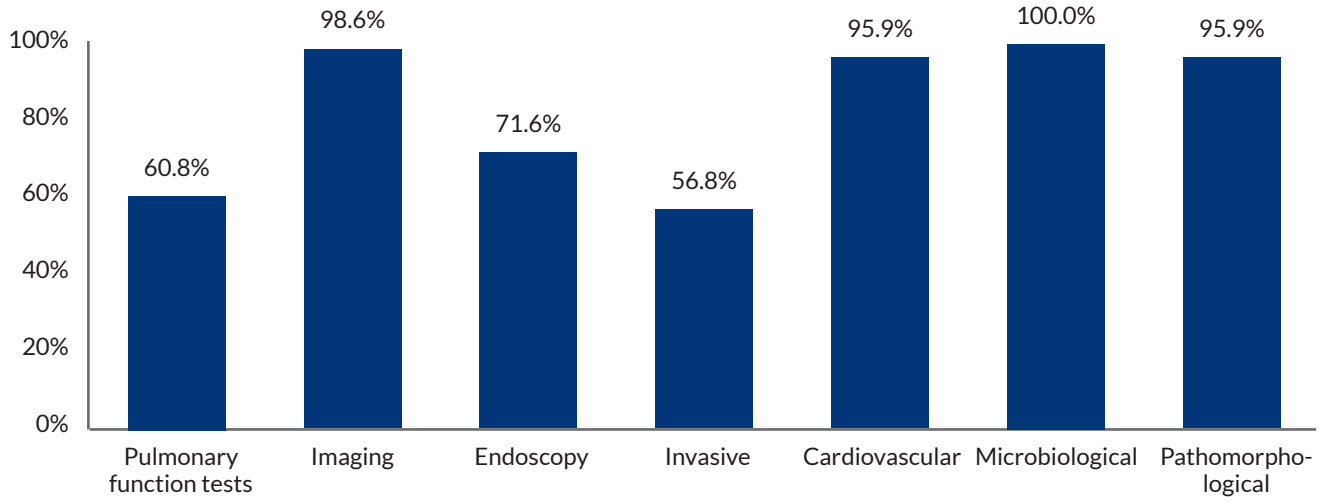


Figure 1. Diagnostic investigations performed at Department of Pulmonology

Table 1. Summary of imaging tests performed at the Department of Pulmonology

Diagnostic imaging	Group (*n* =74)
Chest X-ray	61 (82.4%)
Abdominal US	36 (48.6%)
Chest US	16 (21.6%)
Chest CT	61 (82.4%)
Abdominal CT	0 (0.0%)

Table 2. Suspected etiology of nodular lesions based on radiological examinations performed at the Department of Pulmonology

Tumour type	Group (*n* = 57)
Unknown aetiology	25 (43,9%)
Malignant	20 (35,1%)
Infections, inflammatory and granulomatous lesions	10 (17,5%)
Benign	2 (3,5%)

(9.45%) from the initial study group were ultimately disqualified from invasive procedures due to the advanced stage of the disease, and received conservative treatment instead, while 16 patients (21.6%) were discharged home after completing the diagnosis.

Imaging findings in patients with LC

The following preliminary diagnoses were made in the study group based on radiological findings (tab. 2): suspected malignancy in 20 (35.1%) patients, suspected cancer of unspecified origin in 25 (43.9%) patients, inflammatory and granulomatous lesions or infections in 10 (17.5%) patients. Suspicious benign lesions were found in 2 patients (3.5%). Based on imaging in the Department of Pulmonology, proliferative lung process was suspected in 47 (63.5%) patients. Out of 61 CT scans performed in this centre, the detected lesions did not meet LC radiological criteria in 4 cases.

Endoscopic investigations performed in the Department of Lung Diseases

A total of 54 patients were qualified for endoscopic diagnosis in the Department of Pulmonology, including FOB in 53 (71.6% of the total study group). Gastroscopy was additionally performed in 1 LC patient due to dysphagia.

Invasive investigations performed in the Department of Pulmonology

In addition to endoscopic investigations, other invasive procedures were also performed (fig. 2). Peripheral tumour location within the chest allowed for obtaining specimens for microscopic cytology by means of biopsy of the lung tumour through the chest wall. It was performed in 44.6% of patients. Pleural puncture was performed in 16.2% of patients as an adjuvant to cytological, microbiological and biochemical diagnosis.

Invasive findings in LC patients admitted to the Department of Pulmonology

The diagnostic efficacy for malignancies based on 53 FOBs with specimen collection for histopathology or bronchial brushing (tab. 3) was 35.8%. Transthoracic biopsy of LC was performed in 33 patients, reaching cytological diagnosis of malignancy in 39.4% of cases. Pleural puncture was performed in 12 patients, with the rates of cytological malignant diagnoses of 8.0%. There were no statistically significant differences in the diagnostic efficacy for LC between FOB and lung biopsy (p = 0.7409). Similarly, there were no statistically significant differences in the diagnostic efficacy between FOB and pleural puncture (p = 0.0622). FNAB of the lung tumour was

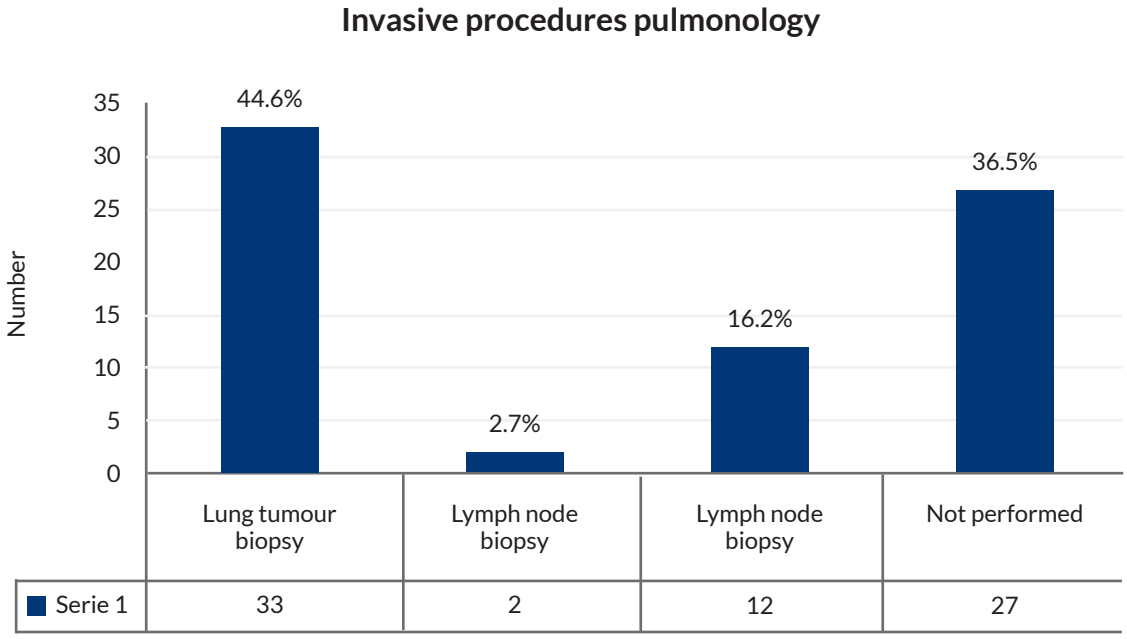


Figure 2. Invasive investigations performed at Department of Pulmonology

a significantly more effective diagnostic approach for malignancies compared to pleural puncture ($p = 0.0466$).

LC aetiology in invasive investigations in the Department of Pulmonology

Pathomorphological investigations performed in the Department of Pulmonology in LC patients, including cytology and histopathology, revealed the following diagnostic categories (tab. 4): no cancer cells ($n = 33$, 44.6%), NSCLC ($n = 21$, 28.4%), squamous cell carcinoma ($n = 9$, 12.2%), adenocarcinoma ($n = 4$, 5.4%), cells with features of atypia/unspecified neoplastic cells ($n = 5$, 6.8%), pleural mesothelioma type cells ($n = 2$, 2.7%), small cell carcinoma ($n = 1$), large cell carcinoma ($n = 1$), and additionally features of inflammation and dysplasia ($n = 11$, 14.9%). Of all diagnoses obtained in pathological examinations, malignant neoplasm was suspected in 43 patients (fig. 3), accounting for 58.1% of all LC patients.

Pulmonary function tests

Pulmonary function tests (PFTs) are one of the key elements of patient qualification for elective invasive procedures in the Department of Pulmonology. Spirometry was performed in 45 (60.8%) patients (tab. 5).

Normal spirometric parameters were found in 16 (35.6%) of these patients. Findings indicating obstructive ventilatory disorders were observed in 28.9% of patients, including moderately severe disorders in 20.0%. Restrictive ventilatory disorders were found in about 13.3% of patients. Plethysmography, as an extension of PFT in patients with suspected restrictive disorders, was performed in 3 (4.1%) patients.

Assessment of selected factors influencing the diagnostic value in the Department of Pulmonology

Univariate and multivariate logistic regression models were performed (tab. 6) to assess the impact of the diagnostic process in the Department of Pulmonology on determining LC aetiology.

All parameters were statistically insignificant in the univariate logistic regression model, while only one parameter (spirometry) was statistically significant ($p = 0.0485$) in the multivariate logistic regression model. Spirometric detection of ventilatory disorders resulted in a reduced likelihood of diagnosing malignancy in masses detected with imaging due to limited respiratory capacity and the risk associated with more aggressive invasive procedures.

Summary of diagnostic approaches for identifying LC aetiology in the Department of Pulmonology

Three basic invasive procedures were used to determine LC origin in the Department of Pulmonology. Cytological or histopathological findings are presented in figure 4. Malignant cells were detected in 35.29% with bronchofiberoscopy, 38.46% with FNAB, and in 8.33% of cases with cytology.

Table 3. Diagnosis of LC based on invasive tests performed at the Department of Pulmonology

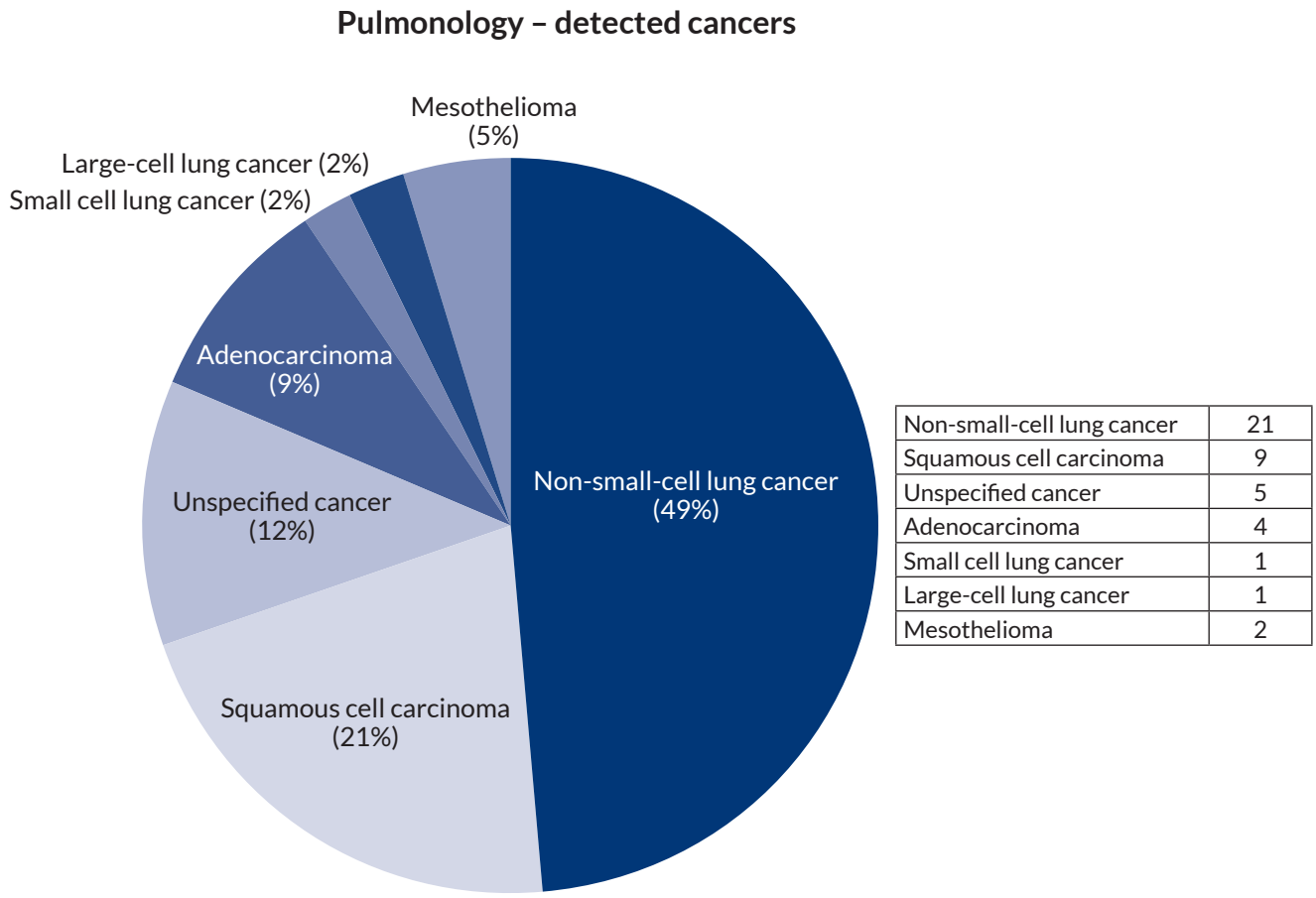
Invasive tests at the Department of Pulmonology	LC diagnostic efficacy (%)
Bronchofiberoscopy	35.8%
Lung biopsy	39.4%
Pleural puncture	8.0%

Table 4. Summary of pathomorphological findings obtained at the Department of Pulmonology

Pathomorphological evaluation	Group ($n = 74$)
Non-Small Cell Lung Cancer	21 (28.4%)
Inflammation, dysplasia	11 (14.9%)
Squamous cell carcinoma	9 (12.2%)
Atypia/indeterminate cancer	5 (6.8%)
Adenocarcinoma	4 (5.4%)
Mesothelioma	2 (2.7%)
Small cell carcinoma	1 (1.4%)
Large cell carcinoma	1 (1.4%)
Insufficient cytological material for pathological evaluation	3 (4.1%)
No cancer cells in the collected specimen	33 (44.6%)

Table 5. Respiratory function findings in the study group

Parameter	Group ($n = 45$)
Normal	16 (35.6%)
Suspected restrictive ventilation disorder	5 (11.1%)
Moderate obstruction	9 (20.0%)
Suspected moderate restrictive ventilation disorder	1 (2.2%)
Mild obstruction	4 (8.9%)



Non-small-cell lung cancer	21
Squamous cell carcinoma	9
Unspecified cancer	5
Adenocarcinoma	4
Small cell lung cancer	1
Large-cell lung cancer	1
Mesothelioma	2

Figure 3. Histological types of malignant tumors detected in pulmonological diagnosis

Comparison of diagnostic quality in the Department of Pulmonology vs. Thoracic Surgery

In the second part of the paper, we attempted to assess the accuracy of pathomorphological diagnoses established in the Department of Pulmonology in LC patients, distinguishing 5 diagnostic categories (tab. 7).

We then correlated these categories with the final histological diagnosis obtained from either invasive diagnostic interventions or LC resection in the Department of Thoracic Surgery, distinguishing between malignant and benign masses (tab. 8).

It was found that NSCLC or SCLC were suspected in 23 patients (45.10%) during pulmonary diagnosis by means of cytological and histopathological evaluation. Tumour resections in the Department of Thoracic Surgery obtained consistent diagnoses in 21 patients (91.30%), with false positive diagnosis in 2 cases (8.7%). Pulmonary diagnosis in the "no neo cells" category was established in 20 patients (39.22%). Malignancy was detected in 10 patients in this group, while benign disease in the remaining 10 (50% each).

In the case of the "other neo" category, established during pulmonary diagnosis in the Department of Thoracic Surgery in 3 patients (5.88%), pleural mesothelioma was diagnosed in 2 cases, and no neoplasm was confirmed in one patient. The "benign" category included 3 cases (5.88%), with confirmed diagnosis in 2 cases, and malignancy ultimately diagnosed in 1 patient. Two "undiagnostic" cases (3.92%) from the Department of Thoracic Surgery were identified as PLC and a benign lesion, respectively.

Table 6. Results of univariate and multivariate logistic regression models

Parameter	Univariate *(P-value)*	Multivariate *(P-value)*
Sex	0.6135	0.8723
Spirometry	0.1115	0.0485
Chest US	0.3522	0.4756
ECG	0.2214	0.6947
Bacteria	0.4966	0.4416
Mycobacterium	0.9970	0.9972
Chest X-ray	0.2044	0.3642

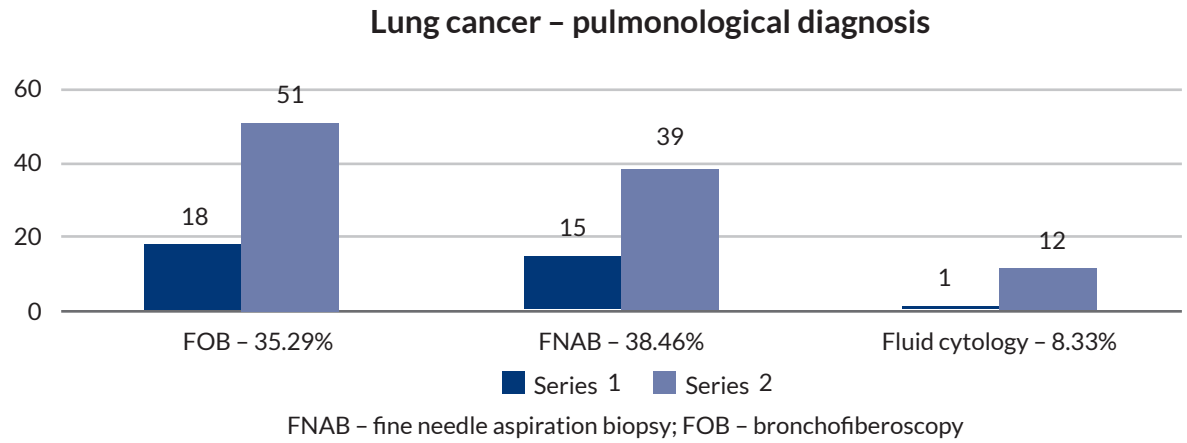


Figure 4. Detection of lung malignancies in invasive pulmonary investigations

In general, among 51 LC patients referred from Pulmonology to Thoracic Surgery, diagnostic concordance was obtained for 36 patients (70.59%). Statistical analysis showed a relationship close to statistical significance (p = 0.0291), confirming the accuracy of pulmonological diagnosis in relation to the final diagnoses from tumour tissues after thoracic surgery. If pulmonological diagnosis raised a preliminary suspicion of malignancy, a high agreement with the final diagnosis was obtained, at the level of statistical significance (p = 0.0018).

In order to determine the value of pulmonary diagnosis performed in the total study group in terms of the accuracy of detecting lung malignancies, diagnoses were classified into the following four categories: true positive (TP), true negative (TN), false positive (FP), false negative (FN).

Table 9 summarises LC diagnostic accuracy in the study group. Considering the pooled data, the following pulmonary diagnostic quality parameters for detecting lung malignancies shown in imaging were obtained:

- accuracy – 0.7059;
- positive predictive value – 0.8846;
- negative predictive value – 0.5200;
- sensitivity – 0.6571;
- specificity – 0.8125;
- informedness – 0.4696;
- markedness – 0.4046.

Table 7. Categories of pathomorphological LC diagnoses established in the Department of Pulmonology

Diagnostic category	Pathomorphological microscopic description
NSCLC/SCLC	The specimen contained primary lung cancer cells (NSCLC or SCLC)
Other cancer	The specimen was suspected to contain cells from cancer other than PLC
Benign	The specimen was suspected to contain benign LC cells
No cancer cells	The specimen contained no cancer cells
Non-diagnostic	Non-diagnostic
NSCLC – non small cell lung cancer; SCLC – small cell lung cancer	

Table 8. Categories of LC diagnoses after thoracic surgery verification

Pulmonological diagnosis	Benign	Cancer	Total
NSCLC/SCLC	2	21	23
	3.92%	41.18%	45.10%
No cancer cells	10	10	20
	19.61%	19.61%	39.22%
Benign	2	1	3
	3.92%	1.96%	5.88%
Other type of cancer	1	2	3
	1.96%	3.92%	5.88%
Non-diagnostic	1	1	2
	1.96%	1.96%	3.92%
Total	16	35	51
	31.37%	68.63%	100.00%
NSCLC – non small cell lung cancer; SCLC – small cell lung cancer			

Evaluation of the optimality of thoracic surgery in LC patients

The type of thoracic surgical approach depended on the diagnosis, stage, and general health status of the patient. Patients underwent one of four types of thoracic surgical procedures: radical, diagnostic-radical, diagnostic, or palliative (tab. 10).

Radical surgery was performed in 24 patients (47.06%). In this subgroup, diagnostic concordance between our centres was obtained for 19 cases (79.16%). The diagnosis differed in 5 cases. However, after performing additional invasive procedures in the Department of Thoracic Surgery (bronchoscopy, pleuroscopy, mediastinoscopy), a diagnosis allowing for radical lung resection was reached. Radical diagnostic procedures, involving an intraoperative assessment of tumour tissues with simultaneous extension of the procedure to radical anatomical lung resection after detecting a tumour, were performed in 7 patients (13.7%). Pulmonological diagnosis suggested a neoplasm in all these patients; however, an intraoperative analysis of paraffin-embedded blocks was additionally needed after assessing the intraoperative image in order to perform anatomical lung resection. Another group of 13 patients (25.49%) were referred to the Department of Thoracic Surgery for diagnosis. The diagnoses were consistent in 7 (53.84%) cases, while they differed in the remaining 6 (46.15%). Ultimately, after performing invasive thoracic surgery procedures, the diagnosis was established in all patients in this group, which allowed for establishing an appropriate path of anti-cancer or pulmonary treatment. Additionally, 7 patients (13.7%) underwent palliative treatment due to advanced disease and accompanying symptoms of respiratory failure caused by pleural effusion, pneumothorax or bronchial obstruction. In this group, the diagnoses were consistent in 3 (42.86%) cases, while they differed in the remaining 4 (57.14%).

When all patients after radical and radical/diagnostic surgeries were considered, it was found that a total of 31 (60.78%) patients from the "radical" and "diagnostic>radical" groups underwent complete LC resection, with diagnostic concordance of 83.87% (26 patients). Among them, 5 (16.13%) patients underwent radical LC resection as a result of complementary invasive diagnosis at the Department of Thoracic Surgery. The cooperation between the pulmonology and thoracic surgery departments in the diagnostic process allowed for surgical procedures with an oncologically optimal extent at a level close to statistical significance ($p = 0.0437$).

It should be noted that if a malignancy was suspected during pulmonological diagnosis, this had a statistically significant impact on the selection of an optimal surgical approach ($p = 0.0029$).

Discussion

In the contemporary literature, there are large discrepancies in the data on the incidence of malignancies among pulmonary nodules detected in imaging, which ranges from 10% to 68% [19]. In the case of screening with low-dose computer tomography (LDCT), the percentage of focal lung lesions is 19.5%, as reported by the European Respiratory Society [20, 21]. Most lung nodules are benign, but it is estimated that malignancies may account for about 20–30% of diagnosed single lung nodules [22].

Modern diagnosis should allow for more effective detection of less advanced lung malignancies, which may enable optimal surgery or other local therapeutic procedures (stereotactic radiotherapy, cyberknife, thermoablation). However, even screening with LDCT allows for detection of almost 85% of advanced LCs (stages III and IV) with high probability, but only 15% of early (stage I and II) LCs [23, 24].

The diagnostic modalities used in the Department of Pulmonology differ in their efficacy for LC. The diagnostic efficiency of FOB for endobronchial lesions is estimated at about 55–60%. However, for peripheral lesions <3 cm, this percentage is 14–50% compared to 46–80% for lesions >3 cm [25–27]. In our study group, FOB detected PLC in 35.92% patients, which was similar to the data presented by the above-cited authors.

Table 9. Individual Accuracy of Pulmonological Diagnosis in Detecting Lung Malignancies

Diagnosis at the Department of Pulmonology Primary diagnosis	Diagnosis at the Department of Thoracic Surgery Department Final diagnosis	Diagnostic accuracy at the Department of Pulmonology
No cancer cells	Benign	TN
No cancer cells	Benign	TN
Non-diagnostic	Cancer	FN
NSCLC/SCLC	Cancer	TP
No cancer cells	Benign	TN
No cancer cells	Benign	TN
No cancer cells	Cancer	FN
No cancer cells	Cancer	FN
No cancer cells	Cancer	FN
Non-diagnostic	Benign	TN)

Table 9. Individual Accuracy of Pulmonological Diagnosis in Detecting Lung Malignancies (cont.)

Diagnosis at the Department of Pulmonology Primary diagnosis	Diagnosis at the Department of Thoracic Surgery Department Final diagnosis	Diagnostic accuracy at the Department of Pulmonology
NSCLC/SCLC	Benign	FN
No cancer cells	Benign	TN
No cancer cells	Benign	TN
NSCLC/SCLC	Cancer	TP
Other cancer	Cancer	TP
Other cancer	Benign	FP
Other cancer	Cancer	TP
NSCLC/SCLC	Cancer	TP
No cancer cells	Cancer	FN
NSCLC/SCLC	Cancer	TP
No cancer cells	Cancer	FN
NSCLC/SCLC	Cancer	TP
No cancer cells	Benign	TN
No cancer cells	Cancer	FN
NSCLC/SCLC	Cancer	TP
NSCLC/SCLC	Cancer	TP
NSCLC/SCLC	Cancer	TP
No cancer cells	Benign	TN
NSCLC/SCLC	Cancer	TP
NSCLC/SCLC	Cancer	TP
NSCLC/SCLC	Cancer	TP
No cancer cells	Cancer	FN
NSCLC/SCLC	Cancer	TP
NSCLC/SCLC	Cancer	TP
NSCLC/SCLC	Cancer	TP
No cancer cells	Benign	TN
NSCLC/SCLC	Cancer	TP
Benign	Benign	TN
NSCLC/SCLC	Cancer	TP
NSCLC/SCLC	Benign	FP
NSCLC/SCLC	Cancer	TP
NSCLC/SCLC	Cancer	TP
NSCLC/SCLC	Cancer	TP
NSCLC/SCLC	Cancer	TP
NSCLC/SCLC	Cancer	TP
No cancer cells	Cancer	FN
No cancer cells	Cancer	FN
Benign	Benign	TN
No cancer cells	Cancer	FN
Benign	Cancer	FN
No cancer cells	Benign	TN

NSCLC – non small cell lung cancer; SCLC – small cell lung cancer; TP – true positive; TN – true negative ; FP – false positive; FN – false negative

Table 10. Types of thoracic surgery by LC diagnostic concordance

Procedure	concordance	diagnostic incompatibility	Total
Radical	19 (37.25%)	5 (9.80%)	24 (47.06%)
Diagnostic>Radical	7 (13.73%)	0 (0.00%)	7 (13.73%)
Diagnostic	7 (13.73%)	6 (11.76%)	13 (25.49%)
Palliative	3 (5.88%)	4 (7.84%)	7 (13.73%)
Total	36 (70.59%)	15 (29.41%)	51 (100.00%)

FNAB is one of the basic tools for the diagnosis of peripheral tumours. The diagnostic efficacy of this approach in lung cancer is estimated at 45–60% [28]. For example, Madan et al. [29] showed that percutaneous FNAB identified approximately 60% of lung nodules as malignant, 30% as inflammatory, 2.5% as granulomas, and 2.5% as suspected of malignancy. The collected material was non-diagnostic in 5% of cases. In our study, the efficacy of FNAB in the pulmonary diagnosis of malignancies was 38.46%.

It is assumed that in advanced cancers with pleural effusion, puncture with fluid cytology allows for the diagnosis of approximately 40–87% of malignant neoplasms [30,31]. In our study, the efficacy of this approach was lower, i.e. 8.33%.

In the last decade, VATS combined with lung biopsy (VATS-LB) was the gold standard in the diagnosis of LC, lymphadenopathy and pleural effusions of unknown aetiology [17]. In the period covered by the author's research, the VATS procedure was taking its first steps in thoracic surgery in our region. Hence, some invasive thoracic procedures were performed via minithoracotomy and, in advanced peripheral tumours and with pleural involvement, using pleuroscopy. It is estimated that the efficacy of lung biopsy reaches 89–95%, and that VATS-LB is characterised by a low risk of complications [32, 33]. Thoracic surgery departments have a larger and more effective arsenal of invasive tools that allow for obtaining diagnostic material from LC and regional nodal or pleural metastases. An undeniable advantage is that in the case of resectable tumours it is possible to combine the collection of a specimen or the entire tumour with an intraoperative evaluation and, if the diagnosis of NSCLC is confirmed, perform a simultaneous anatomical lung resection with regional lymphadenectomy. Marchevsky et al. [34] obtained the following intraoperative diagnostic values for LC, depending on the size of the tumour:

- for tumours <1.1 cm: sensitivity 86.9%, specificity 100%;
- for tumours 1.1–1.5 cm: sensitivity 94.1%, specificity 100%;
- for tumours >1 cm, no false positive diagnoses were found.

However, it should be noted that intraoperative investigation performed within approximately 15–20 minutes of sample collection has its limitations. For paraffin evaluation of small adenocarcinomas with a diameter of less than 3 cm, Yehi et al. [35] achieved a sensitivity of 94% and a relatively low specificity (37%).

In the study by Sileem et al. [36], diagnostic goals in the form of a preliminary preoperative diagnosis of the disease in a group of 146 patients were obtained in 60.3% of cases with FOB with a sensitivity of 45%, 100% with CT-guided FNAB, 75% with sputum cytology, and 78% of cases with EBUS-TBNA. The concordance of the preoperative diagnosis with the diagnosis after thoracic surgery was obtained in 68% of cases; the diagnoses were incorrect in 10%, and incomplete (poorly diagnostic) in 22% of cases.

It can be said that the quality of pulmonological diagnosis in our study group of 51 LC patients after thoracic surgery verification was high. Almost 70.6% of LC patients had a correct diagnosis established in the Department of Pulmonology, which enabled proper choice of further diagnostic and therapeutic strategies. Among patients who underwent optimal lung resection, 83.87% had correct diagnosis established in the Department of Pulmonology, while the remaining 16.13% had an intraoperative histopathological examination performed in the Department of Thoracic Surgery, which allowed for combining the diagnostic and therapeutic procedures.

Based on our study, it was found that cases of lung nodules in which no cancer cells were detected during pulmonary diagnosis require great clinical attention as almost 50% of cases were ultimately diagnosed with malignancy in the Department of Thoracic Surgery.

To conclude, cooperation between a pulmonologist and a thoracic surgeon may be of paramount importance for the rapid and effective identification of LC origin and successful surgical treatment of patients with early-stage disease. In the case of advanced tumours, thoracic surgical diagnosis enables much earlier implementation of systemic anti-cancer treatment.

Conclusions

- The efficacy of invasive diagnostic procedures performed at the Department of Pulmonology for lung malignancies was estimated at 35.8% for bronchofiberoscopy and 39.4% for transthoracic lung biopsy.

- The diagnostic concordance in LC patients who were diagnosed in the Department of Pulmonology and then underwent thoracic surgeries was 70.59%.
- Collaboration of the Department of Pulmonology with complementary thoracic surgery diagnosis for LC detection allowed for optimal extent surgical treatment in 60.7% of patients, with diagnostic concordance of 83.87%.
- The diagnosis of a malignant tumour in the Department of Pulmonology allowed for an optimal thoracic surgery procedure with high statistical significance ($p = 0.0029$).
- Reduced ventilation reserves observed in spirometry in LC patients were negatively correlated with the diagnosis of lung cancer ($p = 0.0485$).

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