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Pneumologia

Analysis of fungal culture positivity rates from sputum, bronchial washing and tissue specimens in cases of thoracic cavity malignancy

Elvando Tunggul Mauliate Simatupang[1], Dewi Anggraini[2], Indra Yovi[1], Zarfiardy Aksa Fauzi[1], Rohani Lasmaria Simbolon[1], Sri Indah Indriani[1]*

[1]Department of Pulmonology and Respiratory Medicine, Faculty of Medicine, Riau University, Pekanbaru, Indonesia
[2]Department of Microbiology, Faculty of Medicine, Riau University, Pekanbaru, Indonesia

Abstract

English:

Background: *Pulmonary mycosis contributes significantly to morbidity and mortality in thoracic malignancies, particularly lung cancer, but diagnosis is often delayed due to non-specific features and limited specimen availability. This study evaluated fungal culture positivity rates from sputum, bronchial washing and tissue specimens in patients with thoracic malignancies in Riau Province.*
Methods: *A cross-sectional analytic study was conducted on 57 patients undergoing bronchoscopy between August 2024 and January 2025. Sputum, bronchial washing and tissue specimens were cultured on Sabouraud Dextrose Agar, with Gram staining, 10% potassium hydroxide (KOH), and Vitek confirmation performed for fungal identification.*
Results: *Overall, 77.19% of specimens were culture positive. Positivity was highest in sputum (57.89%), followed by bronchial washing (56.14%) and tissue (42.11%). Candida sp. predominated in sputum (49.12%, P = 0.002), whereas Aspergillus sp. was most frequently isolated from tissue (28.07%, P = 0.013). Tissue specimens yielded the highest accuracy, while bronchial washing showed 100% sensitivity and 74.47% specificity, outperforming sputum for detecting Candida sp.*
Conclusion: *Fungal culture positivity varies by specimen type in thoracic malignancies. Tissue specimens are optimal for identifying Aspergillus sp., whereas bronchial washing serves as a reliable alternative for Candida sp. Appropriate specimen selection may improve early diagnosis and clinical management of pulmonary mycoses.*

Keywords

fungal culture • positivity • accuracy • thoracic malignancy

Analiza ratelor de pozitivitate a culturilor fungice din spută, spălături bronșice și probe de țesut în cazurile de malignitate ale cavității toracice

Rezumat

Romanian:

Context: *Micozele pulmonare contribuie semnificativ la morbiditatea și mortalitatea asociate malignităților toracice, în special cancerului pulmonar, însă diagnosticul este adesea întârziat din cauza manifestărilor nespecifice și a disponibilității limitate a probelor. Acest studiu a evaluat ratele de pozitivitate ale culturilor fungice din spută, spălătură bronșică și probe de țesut la pacienții cu malignități toracice din provincia Riau.*
Metode: *A fost realizat un studiu analitic transversal pe 57 de pacienți care au efectuat examen bronhoscopic între august 2024 și ianuarie 2025. Probele de spută, spălătură bronșică și țesut au fost cultivate pe mediu Sabouraud dextroză agar, cu efectuarea colorației Gram, a testului cu hidroxid de potasiu 10% (KOH) și a confirmării prin sistemul Vitek pentru identificarea fungilor.*
Rezultate: *Per total, 77.19% dintre probe au fost pozitive la cultură. Cea mai importantă pozitivitate s-a înregistrat în spută (57.89%), urmată de spălătura bronșică (56.14%) și de țesut (42.11%). Candida sp. a predominat în spută (49.12%, P = 0.002), în timp ce Aspergillus sp. a fost cel mai frecvent izolat din țesut (28.07%, P = 0.013). Probele de țesut au oferit cea mai mare acuratețe, în timp ce spălătura bronșică a prezentat o sensibilitate de 100% și o specificitate de 74.47%, depășind detectarea în sputa a Candida sp.*
Concluzie: *Pozitivitatea culturilor fungice variază în funcție de tipul de probă în malignitățile toracice. Probele bioptice (țesut) reprezintă produsul optim pentru identificarea speciilor Aspergillus sp., în timp ce spălătura bronșică reprezintă o alternativă fiabilă pentru detectarea Candida sp. Selectarea adecvată a tipului de probă poate îmbunătăți diagnosticul precoce și managementul clinic al micozelor pulmonare.*

Cuvinte-cheie

Cultură fungică • Pozitivitate • Acuratețe • Malignitate toracică

*Corresponding author: Sri Indah Indriani

E-mail: noniedr@gmail.com

Introduction

Opportunistic pulmonary mycoses significantly increase morbidity and mortality among immunocompromised patients, resulting in over 1.6 million deaths annually from approximately 300 million cases. The global prevalence of this condition remains unclear (1). Factors, such as human immunodeficiency virus (HIV) and chronic diseases, including pulmonary tuberculosis (PTB), lung cancer and respiratory conditions related to smoking or pollution, have contributed to rising caseloads in low and middle income countries (2). In Indonesia, there is a lack of epidemiological data on pulmonary mycosis. Wahyuningsih et al. (1) estimated that it affects 2.89% of the population, equating to about 7.7 million people each year. Furthermore, Rozaliyani et al. (3) discovered fungal cultures in 68.9% of patients with multidrug-resistant tuberculosis (MDR-TB) and 44.5% of those with persistent asthma. Factors, such as chemotherapy, corticosteroids, HIV infection and prolonged antibiotic use, can lead to pulmonary mycosis (4, 5).

Pulmonary mycoses associated with thoracic cavity malignancies, including lung cancer, are often missed due to their similar clinical symptoms and non-specific radiological findings. About 56 of 3.430 lung cancer patients develop chronic pulmonary aspergillosis (CPA) and 2.6% develop invasive pulmonary aspergillosis (IPA) (6–8). *Candida* sp. and *Aspergillus* sp. were the most common fungal isolates in Indonesian lung cancer patients (3, 9). Sputum specimens are still used to diagnose pulmonary mycosis despite their low sensitivity (45%–56%) (10). Arifin Achmad General Hospital, Pekanbaru, found *Aspergillus* sp. in 6.8% and *Candida* sp. in 6.3% of 2.652 inpatients' sputum (11).

Fungal cultures can be improved by using bronchoscopy-derived specimens, such as bronchial washing, brushing, bronchoalveolar lavage (BAL) and tissue, especially in thoracic malignancy. Studies indicate that tissue specimens detect fungal pathogens more accurately than sputum (12, 13). This examination method is rarely used in Indonesia, especially in Riau Province, despite its potential. With this background, this study aims to analyse the positivity rate of fungal cultures from sputum, bronchial washing and tissue specimens in cases of thoracic cavity malignancy in Riau Province.

Methods

Research design

This cross-sectional observational study assessed the positivity rate of fungal cultures obtained from sputum, bronchial washing and tissue samples in patients with thoracic cavity malignancies in Riau Province. The Microbiology Laboratory at the Faculty of Medicine, Riau University, analysed specimens collected during bronchoscopy procedures conducted at Arifin Achmad General Hospital in Riau Province. The study, scheduled to run from August 2024 to January 2025, received approval from the Ethics Committee of the Faculty of Medicine, Riau University, under Ethical Clearance Number B/III/UN19.5.1.1.8.UEPKK/2024.

Research population

This study involved patients with thoracic cavity malignancies who had clinical indications and were eligible for bronchoscopy. A total of 57 patients who met the inclusion and exclusion criteria were sampled consecutively, without stratification or randomisation. The study included adult patients who were clinically and radiologically diagnosed with thoracic cavity malignancy and had indications for bronchoscopy. Exclusions were made for patients with pulmonary mycosis, those who were taking antifungal medications and those who did not have sputum, bronchial washing, or tissue samples available.

Research instrument

Sputum specimens are collected prior to bronchoscopy, while bronchial washings and tissue are taken during the bronchoscopy procedure. Tissue specimens were collected by bronchial brushing or forceps. All specimens were grown on Sabouraud Dextrose Agar medium and incubated at 25°C for 1–5 days for macroscopic growth observation. The growth of yeast fungi was analysed by Gram staining, while that of mould fungi was examined by 10% *potassium hydroxide* (KOH). Yeast fungi findings, along with gram-negative/positive bacteria, after day 5, were considered non-pathogenic fungi. Fungal culture was positive if yeast/budding cells were found on the Gram stain and confirmed with VITEK® system (bioMérieux SA, Marcy-l'Étoile, France) for identification of fungal species. Microscopically intact hyphae on a 10% KOH examination are also considered a positive result.

Research analysis

The different fungal species identifications between the sputum, bronchial washings and tissues were followed by data analysis using IBM SPSS Statistics (IBM Corp., Armonk, NY, USA) software. Univariate analysis was conducted to determine the frequency distribution and was presented in the form of tables or diagrams. Furthermore, all variables were subjected to bivariate analysis using the chi-square test with an alternative Fisher test. A value of $P < 0.05$ is considered statistically significant and appropriate.

Results

Between August 2024 and January 2025, 145 patients were hospitalised due to thoracic cavity malignancy. Out of these, 66

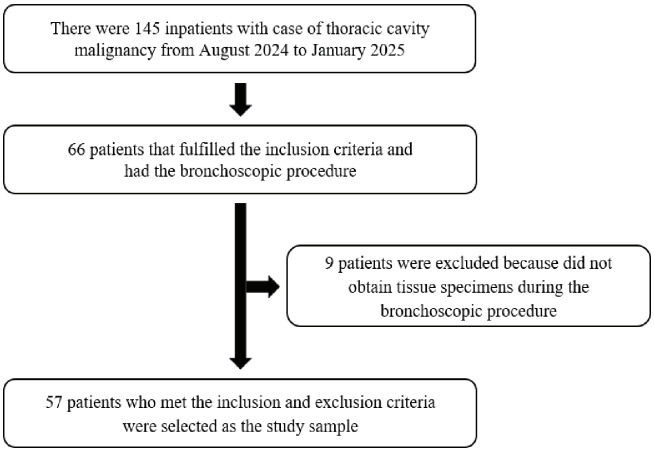

Figure 1. Research sample selection.

underwent bronchoscopy, and 57 patients who met the inclusion and exclusion criteria were included in the study (Figure 1).

Table 1 shows that most patients were over the age of 40 years old (91.23%), predominantly male (66.67%), and classified as underweight (49.12%). Additionally, a significant proportion were smokers with a high Brinkman Index (50.88%). A total of 50.88% of patients reported no history of pulmonary disease, and 66.67% had no comorbidities. Patients used bronchodilators, either with or without inhaled corticosteroids, 40.35% of the time. Chronic cough (84.21%) and moderate cancer pain (45.61%) were the primary symptoms observed. Most cases of thoracic cavity malignancy (91.23%) were diagnosed as lung cancer, with adenocarcinoma accounting for 36.94%. Fungal culture results were positive in 77.19% of the 57 patients with thoracic cavity malignancy.

Positivity rate of fungal cultures

A total of 44 out of 57 patients (77.19%) showed positive fungal culture results from at least one of the test specimens used in this study. As shown in Figure 2, the most identified fungi were *Candida* sp. (57.89%), *Aspergillus* sp. (31.58%), *Cryptococcus* sp. (3.51%) and *Epicoccum* sp. (1.75%).

Figure 3 shows that sputum specimens had the highest positivity rate at 57.89%, followed by bronchial washing at 56.14% and tissue samples at 42.11%. The positivity rates of fungal cultures differed significantly across the types of specimens (Figure 4).

The positivity rate of *Candida* sp. differed significantly among the three specimen types (P = 0.002), with sputum showing the highest rate (49.12%). Similarly, the positivity rate of *Aspergillus* sp. also differed significantly (P = 0.013), with tissue samples demonstrating the highest distribution. No significant difference was observed for *Cryptococcus* sp. among the specimens (P = 1.000), while *Epicoccum* sp. was exclusively identified in tissue samples (Figure 4).

Table 1. Characteristics of research subjects

Variables	*N*	%
Age (years)		
• ≤40	5	8.77
• >40	52	91.23
Gender		
• Male	38	66.67
• Female	19	33.33
BMI (kg/m^2)		
• Underweight	28	49.12
• Normoweight	20	35.09
• Overweight	4	7.02
• Obesity class I	4	7.02
• Obesity class II	1	1.75
Smoking status		
• Non-smoker	19	33.33
• Mild brinkman index	3	5.26
• Medium brinkman index	6	10.53
• Severe brinkman index	29	50.88
History of pulmonary disease		
• None	29	50.88
• Former TB	5	8.77
• COPD	23	40.35
Comorbidity		
• None	38	66.67
• Hypertension	12	21.05
• Diabetes mellitus type 2	4	7.02
• Heart failure	4	7.02
• Stroke	1	1.75
• Autoimmune disease	1	1.75
Drug history		
• None	17	29.82
• Bronchodilators with/without inhaled corticosteroids	23	40.35
• Anti-tuberculosis drugs	5	8.77
• Anti-hypertensives	16	28.07
• Anti-diabetics	4	7.02
• Oral corticosteroids	1	1.75
Clinical symptoms		
• Shortness of breath	23	40.35
• Chest pain	47	82.46
• Chronic cough	48	84.21
• Haemoptysis	5	8.77
Cancer pain degree		
• No pain	10	17.54
• Mild	17	29.82
• Moderate	26	45.61
• Severe	4	7.02
Types of thoracic cavity malignancy		
• Lung cancer	52	91.23
• Mediastinal tumour	2	3.51
• Lung tumour metastasis	3	5.26
Pathology anatomy results		
• Cancer type unknown	16	28.07
• Adenocarcinoma	21	36.84
• Squamous cell carcinoma	14	24.56
• Neuroendocrine carcinoma	3	5.26
• Tumour metastasis in lungs	3	5.26
Fungal culture results		
• Positive culture	44	77.19
• Negative culture	13	21.81

BMI, body mass index; COPD, chronic obstructive pulmonary disease; TB, tuberculosis.

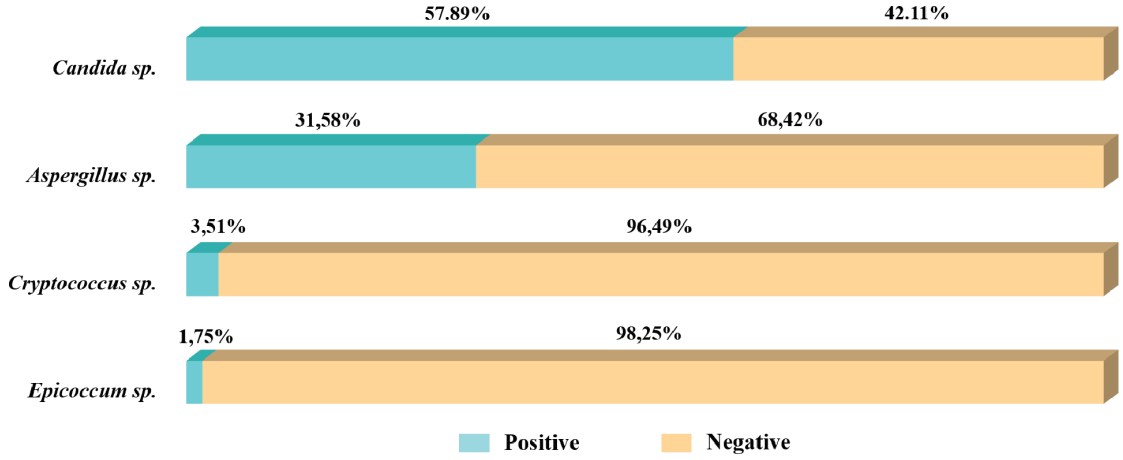

Figure 2. Fungus positivity rates based on research subjects.

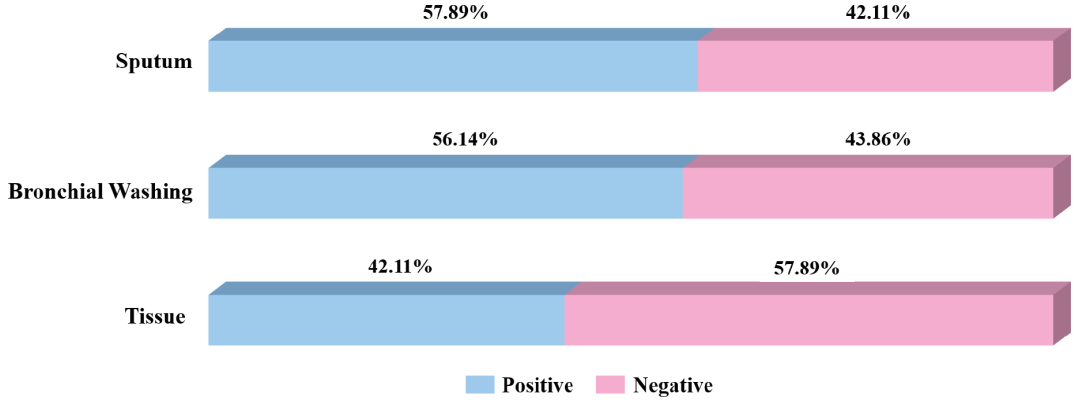

Figure 3. Fungus positivity rates based on research subjects.

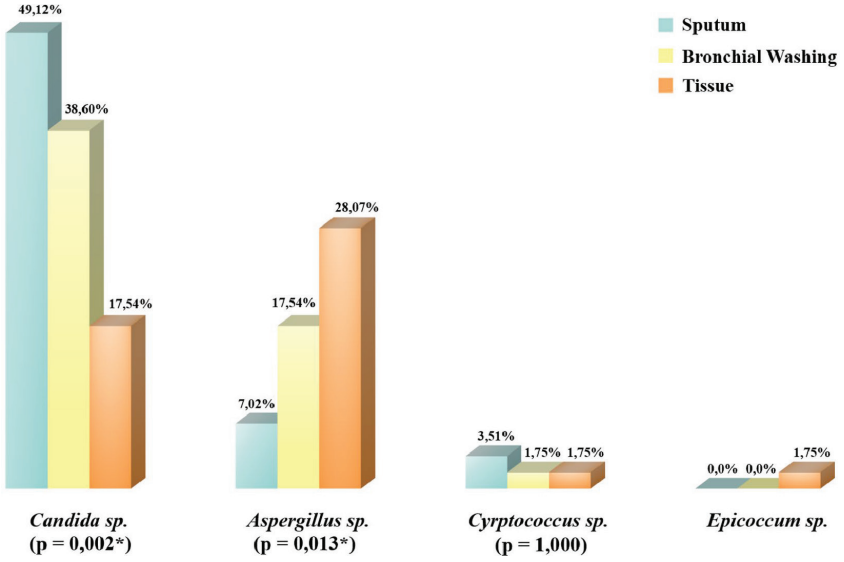

Figure 4. Analysis of culture positivity rate and fungal species.

Analysis of test specimen concordance to fungal culture positivity

This study found that the positivity rates for sputum, bronchial washing and tissue specimens were similar. Tissue samples were utilised for all fungal culture identifications. However, the positivity rates for *Candida* sp. and *Aspergillus* sp. varied significantly across the three specimen types, reflecting their concordance patterns. Of the *Candida* sp. positivity cases, 21.22% were identified in all three specimen types, while 33.33% were detected only in sputum. Figure 5A illustrates that tissue specimens, considered the gold standard, had a lower positivity rate for *Candida* sp. compared to sputum and bronchial washing specimens. In contrast, *Aspergillus* sp. exhibited a concordance positivity distribution of 22.22% across all three specimen types, with a higher rate of 44.45% for tissue specimens. Figure 5B demonstrates that tissue specimens, as the gold standard, were more likely to test positive for *Aspergillus* sp. than either sputum or bronchial washing specimens.

Accuracy of test specimens for fungal culture positivity

Table 2 compares the diagnostic accuracy of sputum and bronchial washing specimens with that of tissue specimens, which are considered the gold standard. The accuracy measures include sensitivity, specificity, positive predictive value (PPV) and negative predictive value (NPV). Sputum samples showed 70% sensitivity, 55.32% specificity and a 25% PPV for detecting *Candida* sp. In comparison, bronchial washing specimens exhibited 100% sensitivity, 74.47% specificity and a 45.46% PPV for *Candida* sp. detection, outperforming sputum specimens. For *Aspergillus* sp., sputum specimens had a sensitivity of 25% but demonstrated 100% specificity and PPV, while bronchial washing specimens revealed 50% sensitivity, 95.12% specificity and 80% PPV.

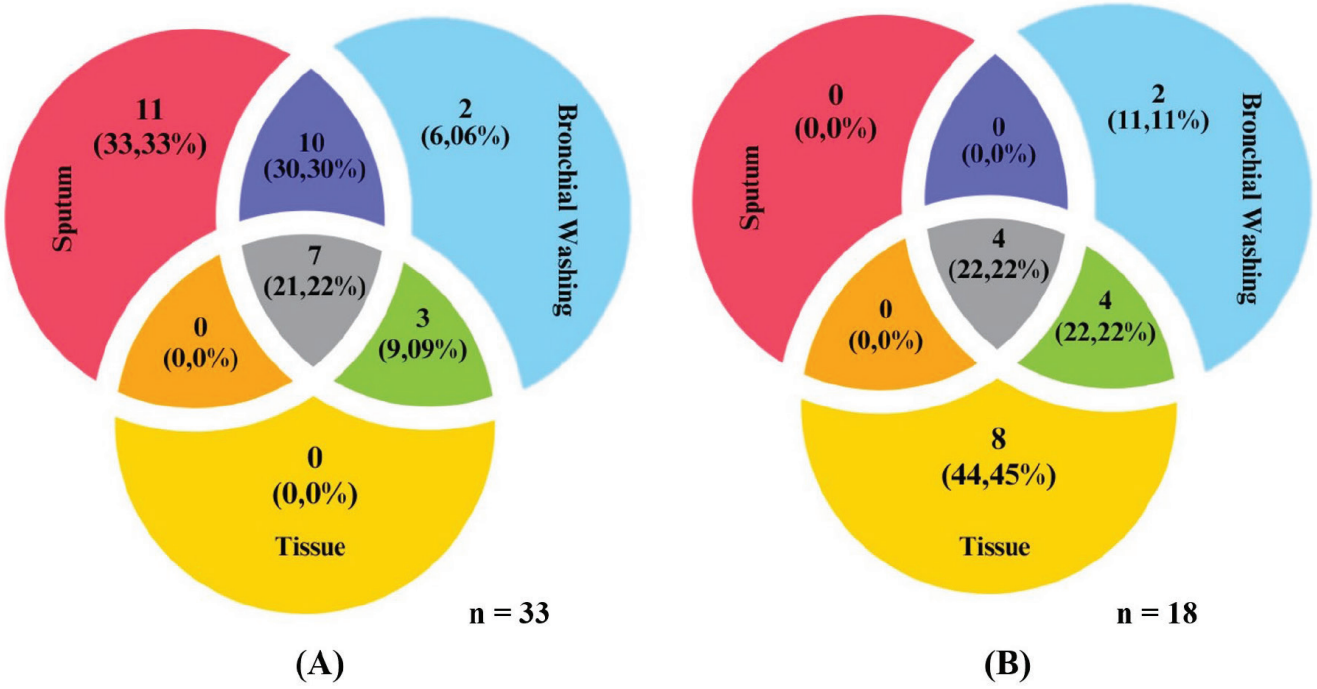

Figure 5. Analysis of culture positivity rate and fungal species. (A) *Candida* sp. (B) *Aspergillus* sp.

Table 2. Accuracy of test specimens for fungal culture positivity

Isolate	Sputum versus tissue				Bronchial washing versus tissue			
	Sn (%)	Sp (%)	PPV (%)	NPV (%)	Sn (%)	Sp (%)	PPV (%)	NPV (%)
Candida sp.	70.0	55.32	25.0	89.66	100.0	74.47	45.46	100.0
Aspergillus sp.	25.0	100.0	100.0	77.36	50.0	95.12	80.0	82.98
Cryptococcus sp.	100.0	98.21	50.0	100.0	100.0	100.0	100.0	100.0
Epicoccum sp.	0.0	100.0	0.0	98.25	0.0	100.0	0.0	98.25

NPV, negative predictive value; PPV, positive predictive value; Sn, sensitivity; Sp, specificity.

Both sputum and bronchial washing specimens detected *Cryptococcus* sp. with high sensitivity and specificity. Bronchial washing showed a PPV of 100%, exceeding that of sputum. *Epicoccum* sp. had 100% specificity and a 98.25% NPV but a sensitivity of 0%. Table 2 indicates that tissue specimens were more accurate than both sputum and bronchial washing specimens in identifying fungal cultures, especially for *Aspergillus* sp. and *Epicoccum* sp. In patients with thoracic cavity malignancies, bronchial washing may effectively detect *Candida* sp. and *Cryptococcus* sp.

Discussion

Most respondents (91.23%) were over 40 years old, with 66.67% identifying as male. These findings align with the research of Pradnyaandara et al. (14) and Alfarisa et al. (15), which indicates that lung cancer is the most prevalent malignancy of the thoracic cavity among older men. In this study, a significant portion of patients (49.12%) were classified as underweight according to their body mass index (BMI). Malnutrition can potentially accelerate disease progression, increase fungal colonization, elevate mortality rates and diminish tolerance to treatment (16–18).

A severe Brinkman index (50.88%) among participants suggests that smoking is a significant risk factor for lung cancer (19, 20). Chronic inflammation, particularly among those with a history of chronic obstructive pulmonary disease (COPD) (40.35%), further raises the risk of lung cancer. Research indicates that 50–90% of lung cancer patients also have COPD. This condition leads to cellular mutations that foster cancer cell growth, driven by chronic inflammation, oxidative stress, and lung tissue remodelling. Additionally, the hypersecretion associated with COPD contributes to sputum and biofilm formation, creating an environment conducive to microorganism colonisation (19, 21, 22).

Comorbidities were identified in 66.67% of patients, with hypertension being the most prevalent condition associated with thoracic cavity malignancy, occurring in 21.05% of cases. These findings align with those of El-Badrawy et al. (23), who reported that 38% of lung cancer patients had no comorbidities. Additionally, Gupta et al. (24) found that 50% of lung cancer patients were diagnosed with hypertension. This study indicates that the use of bronchodilators, with or without inhaled corticosteroids (40.35%), is associated with an increased risk of fungal colonisation. This, in turn, may lead to a reduction in alveolar macrophage function and proinflammatory cytokines, which inhibits fungal colonisation in lung parenchyma (25, 26).

Chronic cough (84.21%) and chest pain (82.46%) emerged as the primary symptoms, potentially indicating pulmonary mycosis. Chronic coughing can result from impaired mucociliary clearance due to ongoing inflammation. The invasion of hyphae into lung epithelial tissue and blood vessel endothelium can lead to chest pain and lung infarction (27, 28). This study also identified lung adenocarcinoma (36.84%) as the most common type of thoracic malignancy. These findings are consistent with several studies indicating that lung adenocarcinoma is frequently associated with fungal colonisation (29, 30). Harada et al. (31) reported that 50% of adenocarcinomas were present in 85% of cases involving fungal colonisation in lung cancer patients.

El-Badrawy et al. (23) reported a fungal culture positivity rate of 68% among 100 lung cancer patients, which is comparable to the 77.19% observed in this study. The investigation identified the presence of *Candida* sp., *Aspergillus* sp., *Cryptococcus* sp. and *Epicoccum* sp. fungi in three test specimens. Specifically, *Candida* sp. constituted 59.65% and *Aspergillus* sp. 31.58% of the identified fungi. These findings align with those of Laroumagne et al. (30), who documented a positivity rate of 42.9% for *Candida* sp. and 6.2% for *Aspergillus* sp. across all lung cancer cases. Conversely, El-Badrawy et al. (23) found *Aspergillus* sp. in 36% and *Candida* sp. in 32% of the lung cancer patients.

Cryptococcus sp. (3.51%) and *Epicoccum* sp. (1.75%) are additional common findings in fungal cultures related to thoracic cavity malignancies. Immunosuppression is frequently associated with *Cryptococcus* sp. (32). Meanwhile, *Epicoccum* sp. is typically found in soil, dust and plants as a contaminant, with limited evidence supporting its role in pulmonary mycosis. Variations in fungal culture results may be attributed to the use of different test specimens, each exhibiting distinct sensitivities and specificities (33).

Fungal cultures showed positivity in 57.89% of 33 sputum, 56.14% of 32 bronchial washing and 42.11% of 24 tissue. Among 216 immunocompromised patients, the highest positivity rates were found in sputum (64.3%), bronchial washing (30.6%) and tissue (5.0%), as reported by Nugratama et al. (34). The diagnostic accuracy of each specimen type may influence positivity rates. Most positive fungal cultures were obtained from specimens of bronchial washing and tissue during bronchoscopy. In a study involving 98 lung cancer patients, Gupta et al. (24) reported that most fungal cultures were identified through bronchoscopy, with a positivity rate of 65.31% for BAL and 61.22% for bronchial washing. Ayçiçek et al. (29) found a fungal culture positivity rate of 16.4% from bronchoscopy compared to 15.3% from sputum.

Sputum cultures can be more positive due to contamination, specimen quality and fungal culture incubation time (24, 35). This study found low positivity in tissue samples, possibly due to damage to fungal cells or their components during collection, which could affect fungal cultures (36). The three sputum samples had different fungal culture positivity (P = 0.002).

Sputum samples were most positive for *Candida* sp. (49.12%) and least positive for *Aspergillus* sp. (17.54%). According to Prakash et al. (37), immunocompromised patients had a 54% *Candida* sp. positivity rate with a *P*-value of 0.0001. Similarly, Sahara et al. (38) found *Candida* sp. in 80% of lung cancer patients. The humid upper airway and *Candida* sp. ability to colonise may explain the increased presence of these organisms in sputum. Positive results in fungal cultures are often considered contaminants (39).

The three tissue specimens showed significant variance in fungal culture prevalence, with *Aspergillus* sp. (28.07%) and *Candida* sp. (7.02%) having the highest and lowest prevalence ($P = 0.013$). In biopsy forceps specimens from lung cancer patients, Ayçiçek et al. (29) found 22.81% *Aspergillus* sp. positivity, significantly higher than bronchial washing ($P < 0.001$). Denning et al. (40) found *Aspergillus* sp. in 31.57% of biopsy tissues. *Aspergillus* sp., the most common pulmonary pathogenic fungus, penetrates epithelial and parenchymal tissue. Damage to the airway epithelium and lung parenchyma is the main cause of *Aspergillus* sp. colonisation and lung lesions. This confirms that tissue specimens are more often used to identify *Aspergillus* sp. than sputum or bronchial washing (41).

The results indicated no statistical significance ($P = 0.000$), although sputum samples revealed a higher percentage of *Cryptococcus* sp. (3.51%). *Epicoccum* sp. was identified with 100% accuracy in tissue samples. The low quantities of *Cryptococcus* sp. and *Epicoccum* sp. observed in this study led to statistically biased outcomes. Tissue specimens demonstrated greater reliability in detecting various fungi, particularly *Aspergillus* sp. and *Epicoccum* sp., while sputum specimens were mainly positive for *Candida* sp. and *Cryptococcus* sp. (32, 33).

This study compares sputum and bronchial washing specimens to tissue specimens, which are considered the gold standard for diagnosing malignancies in the thoracic cavity, in terms of fungal culture results. The positivity rate for *Candida* sp. in sputum (33.33%) was higher than that in tissue specimens (21.22%) (Figure 5A). Despite tissue specimens being the gold standard, they exhibit a lower positivity rate for *Candida* sp. The concordance analysis suggests that a high rate of *Candida* sp. positivity may result in false positives due to contamination or normal flora (33). *Candida* sp. can penetrate the airway epithelium by transitioning from yeast to hyphal form, which is attributed to their unique properties. Additionally, cancer necrosis facilitates the formation of biofilms by *Candida* sp., enabling them to invade adjacent organs. The positivity for *Candida* sp. in tissue specimens indicates high accuracy (29, 42).

Aspergillus sp. positivity was lower in sputum (0%) and bronchial washing (11.11%). All three test specimens had the same 21.22% *Aspergillus* sp. positivity rate. This suggests that sputum and bronchial washing positivity yield similar tissue results. If obtained exclusively from tissue specimens, *Aspergillus* sp. had 44.45% positivity (Figure 5B). *Aspergillus* sp. positivity is more common in tissue specimens, the gold standard, than in sputum and bronchial washing. *Aspergillus* sp. can invade and penetrate the lung epithelium and parenchyma, which increases its positivity in tissue specimens. Additionally, *Aspergillus* sp. can invade blood vessels and nearby organs (43, 44).

This study identified differences in the accuracy of diagnostic tests among the three specimens examined. Sputum and bronchial washing were found to be less accurate than tissue specimens in identifying all fungal species. Factors, such as the specimen collection technique, insufficient sample sizes and challenges in identifying fungal species, contributed to bias in the accuracy of the three test specimens (45, 46). Power et al. (47) defined a diagnostic test as useful if its sensitivity and specificity are both less than 150%. Other interpretations suggest that diagnostic tests with sensitivity and specificity values of £100% are likely ineffective. Conversely, diagnostic test results approaching 200% are considered optimal and highly recommended.

Many studies indicate that tissue specimens demonstrate greater sensitivity and specificity compared to sputum and bronchial washing for detecting fungal cultures, particularly *Aspergillus* sp. in lung cancer (43, 44). Tissue specimens yield more positive results for *Aspergillus* sp. because the fungus can invade the airway epithelium and lung parenchyma (45, 48). The results of diagnostic tests align with the analysis of specimen efficacy, indicating that tissue specimens produce the highest number of positive *Aspergillus* sp. culture results, whereas sputum and bronchial washing yield fewer positive results (44).

This study's sputum specificity (55.32%) is lower than that of bronchial washing (74.47%), aligning with Kontoyiannis et al. (49), which reported a specificity of 60%. The discrepancy may be attributed to factors such as sputum sample contamination, poor quality and inadequate culture time. *Candida* sp. can transition from yeast to hyphal forms, facilitating their penetration of the airway epithelium. This characteristic may explain why bronchial washing demonstrates greater specificity than sputum samples. Additionally, necrosis induced by malignancy may contribute to the formation of biofilms by *Candida* sp., enabling them to invade lung parenchyma (24, 50).

Conclusion

Fungal culture positivity rates varied significantly among research subjects and test specimens, particularly sputum,

bronchial washing and tissue samples. This study identified statistically significant differences in positivity rates for *Candida* sp. and *Aspergillus* sp. across the three specimen types, with sputum exhibiting the highest levels for *Candida* sp. and tissue specimens showing the highest levels for *Aspergillus* sp. Tissue specimens demonstrate higher diagnostic accuracy than sputum or bronchial washing for fungal culture identification, particularly for *Aspergillus* sp. and *Epicoccum* sp. Additionally, bronchial washing specimens may serve as a substitute for sputum in detecting *Candida* sp. and *Cryptococcus* sp. in patients with thoracic cavity malignancies.

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Author's contribution

ETMS, SII and DA contributed to the idea and concept. ETMS contributed to design, manuscript writing, data collection and processing. SII and DW contributed to control and supervision. ETMS, SII, DA, IY, ZAF and RLS equally contributed to review and revision. All authors contributed to and approved the final version of the manuscript.

Conflict of interest

The authors declare there is no conflict of interest.

Ethical declaration

The study was approved by the Ethics Committee of the Faculty of Medicine at Riau University, under Ethical Clearance Number B/III/UN19.5.1.1.8.UEPKK/2024.

Informed consent statement

Informed consent was obtained from the subjects involved in the study.

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