Clinical Diagnostic Value and Accuracy of Microbiological Testing for Pulmonary Aspergillosis Infection

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DOI: 10.32629/jcmr.v5i3.2644

Abstract: Objective: To analyze the clinical diagnostic value and accuracy of microbiological testing for pulmonary aspergillosis infection.Methods: Sixty patients suspected of having pulmonary aspergillosis infection from January 2023 to June 2024 were selected. All selected patients underwent sputum culture test, galactomannan test (GM test), and 1,3-β-D-glucose (BDG) test (referred to as G test). Pathological histology examination was used as the gold standard to evaluate the diagnostic value and accuracy of sputum culture test, GM test, and G test in pulmonary aspergillosis infection. Results: In this study, histopathological examination of 60 patients showed 35 positive cases and 25 negative cases of pulmonary aspergillosis infection. The sputum culture test results showed that there were 34 positive cases, 26 negative cases, 7 false positives, and 6 false negatives of pulmonary aspergillosis infection. The GM test results showed that there were 34 positive cases, 26 negative cases, 3 false positives, and 2 false negatives of pulmonary aspergillosis infection. The G test results showed that there were 34 positive cases, 26 negative cases, 8 false positives, and 7 false negatives of pulmonary aspergillosis infection. The sensitivity, specificity, accuracy, positive predictive value, and negative predictive value of the GM test were significantly higher than those of the sputum culture test and G test ($P<0.05$). Conclusion: The diagnostic value of the GM test in pulmonary aspergillosis infection is higher than the sputum culture test and G test, and it can be widely used.
***Keywords*:** pulmonary infection; Aspergillus; microbial testing

1. Introduction

Aspergillus is an opportunistic pathogenic fungus that is widely present in nature. When humans are infected with Aspergillus, it can cause aspergillosis, posing a significant threat to human health. The lungs are the most common site of Aspergillus infection, which can cause symptoms such as coughing, sputum production, hemoptysis, wheezing, and chest pain[1]. Currently, clinical treatment for this disease mainly involves medication or surgery, and most patients can be cured with standardized treatment. However, the clinical symptoms of this disease lack specificity and can easily be confused with other pulmonary diseases such as bacterial infections or tuberculosis, delaying clinical treatment. Therefore, effective auxiliary diagnostic methods are needed for timely screening and treatment, thereby improving patient prognosis[2]. Currently, pathological examination is considered the gold standard for diagnosing this disease, but it is an invasive procedure typically used as the final diagnostic method, making it unsuitable for the initial screening of emergency patients. Microbiological testing is a common method for screening fungal infections, with commonly used techniques including sputum smear examination, fungal culture, Aspergillus antigen detection, and detection of fungal cell wall components. Sputum culture is the most commonly used method for diagnosing aspergillosis in clinical settings. Although the results can assist in clinical diagnosis, the positive rate of sputum culture is low, a single culture result cannot definitively diagnose the disease, and a negative result does not rule out the disease, indicating certain limitations[3]. The GM test mainly screens for Aspergillus infection by detecting the content of galactomannan in samples. Galactomannan is an important component of the Aspergillus cell wall that is gradually released after fungal invasion of the lungs and reaches its peak 3-4 days after infection. Enzyme-linked immunosorbent assay (ELISA) can be used to screen for GM content, thereby improving the detection rate of Aspergillus. However, this method may also be influenced by factors such as food or medication, leading to false positives[4]. The G test is another screening method that detects fungal cell wall components, specifically 1,3-β-D-glucan (BDG), which is widely present in the cell walls of fungi. Although the G test can screen for Aspergillus infection, the use of antibiotics may affect its accuracy.To observe the application value of different microbiological testing methods in pulmonary Aspergillus infection, this study selected 60 patients suspected of having pulmonary Aspergillus infection from January 2023 to June 2024 for comparative observation, as detailed below.

2. Materials and Methods

2.1 Clinical Data

Sixty patients suspected of having pulmonary Aspergillus infection from January 2023 to June 2024 were selected, including 36 males and 24 females, aged 22 to 85 years, with an average age of (54.3 ± 4.2) years. Inclusion criteria: patients presenting with symptoms such as cough, sputum production, fever, hemoptysis, wheezing, and chest pain, who were unresponsive to empirical antibiotic treatment; patients initially assessed as having suspected pulmonary Aspergillus infection; patients who provided informed consent for the study. Exclusion criteria: patients with concurrent tuberculosis or lung tumors.

2.2 Methods

All selected patients underwent sputum culture, galactomannan (GM) test, and 1,3-β-D-glucan (BDG) test (G test). ① Sputum Culture: Patients were instructed to clean their mouths before expectorating sputum. The sputum was inoculated onto Sabouraud agar plates and incubated at 36°C for 24 hours. After 24 hours, the colony morphology and color were observed. If black radial cylindrical colonies, green and yellow-brown cylindrical colonies, or blue-gray and gray-yellow cylindrical colonies appeared, the result was preliminarily judged as positive. ② GM Test: 5 mL of elbow venous blood was collected in the morning while fasting. The blood was centrifuged at 2500 r/min for 10 minutes with a centrifugal radius of 10 cm, and the upper serum layer was collected for testing. The enzyme-linked immunosorbent assay (ELISA) was used to detect the galactomannan antigen (GM) in the samples. A GM level > 10.5 ng/L was considered positive. ③ G Test: Pulmonary alveolar lavage was performed by a doctor using a bronchoscope, with saline used as the lavage fluid. After obtaining the lavage fluid, it was inoculated onto Sabouraud agar plates and incubated at 36°C for 24 hours. After 24 hours, the colony morphology and color were observed. The strains similar to fungal samples were prepared and stained with cotton blue dye for microscopic examination. If the hyphal branches were > 45° and the glucose content was > 10 pg/mL, the result was considered positive.

2.3 Observation Indicators

With pathological histological examination as the gold standard, the diagnostic value and accuracy of sputum culture, GM test, and G test in pulmonary Aspergillus infection were evaluated.

2.4 Statistical Analysis

Statistical analysis was performed using SPSS 22.0 software. A P-value < 0.05 was considered statistically significant.

3. Results

3.1 Comparison of Three Microbiological Test Methods with Pathological Examination Results

In this study, among the 60 patients, pathological histological examination showed 35 positive cases and 25 negative cases for pulmonary Aspergillus infection. The results of the sputum culture showed 34 positive and 26 negative cases, with 7 false positives and 6 false negatives. The GM test showed 34 positive and 26 negative cases, with 3 false positives and 2 false negatives. The G test showed 34 positive and 26 negative cases, with 8 false positives and 7 false negatives. Details are shown in Tables 1, 2, and 3.

Table 1. Comparison of Sputum Culture and Pathological Examination Results

Pathological Examination	Sputum Culture		Total
	Positive	Negative	
Positive	28	7	35
Negative	6	19	25
Total	34	26	60

Table 2. Comparison of GM Test and Pathological Examination Results

Pathological Examination	GM Test		Total
	Positive	Negative	
Positive	32	3	35
Negative	2	23	25
Total	34	26	60

Table 3. Comparison of G Test and Pathological Examination Results

Pathological Examination	G Test		Total
	Positive	Negative	
Positive	27	8	35
Negative	7	18	25
Total	34	26	60

3.2 Differences in Diagnostic Value Among the Three Microbiological Testing Methods

The GM test demonstrated higher sensitivity, specificity, accuracy, positive predictive value, and negative predictive value compared to sputum culture and G test, with significant differences ($P < 0.05$), as shown in Table 4.

Table 4. Diagnostic Value of Three Microbiological Testing Methods (%)

Method	Sensitivity	Specificity	Accuracy	Positive Predictive Value	Negative Predictive Value
Sputum Culture	80.0	76.0	78.3	82.4	73.1
GM Test	91.4	92.0	91.7	94.1	88.5
G Test	77.1	72.0	75.0	79.4	69.2
F Value	5.132	5.246	5.264	5.326	5.114
P Value	0.041	0.042	0.042	0.043	0.041

4. Discussion

In recent years, the incidence of pulmonary aspergillosis has been increasing in China, particularly among immunocompromised individuals and those exposed to harsh working environments. Aspergillus fungi are widely present in the natural environment. When the immune system is compromised, or when patients are on corticosteroids or antibiotics, inhaled Aspergillus spores may not be effectively cleared, leading to pulmonary aspergillosis [5]. Pulmonary aspergillosis can cause various pathologies, including acute invasive pulmonary aspergillosis, chronic necrotizing pulmonary aspergillosis, and invasive aspergillosis of the airways. Symptoms often include cough, sputum production, fever, and wheezing, with severe cases potentially leading to respiratory failure and posing a significant threat to patient health. Currently, clinical management primarily involves antifungal medications, with some cases requiring surgical intervention [6]. Early diagnosis and treatment are critical to improving patient outcomes. Therefore, effective diagnostic methods are needed for timely diagnosis and intervention.

Microbiological testing is a common approach for screening fungal infections, with various methods available, each with its own advantages and limitations. Sputum culture is a standard method for diagnosing fungal infections but is time-consuming and labor-intensive. It can be affected by operator skill and laboratory conditions, and has a relatively low positive rate. The GM test detects galactomannan, a key component of the Aspergillus cell wall, which is released into the bloodstream following fungal invasion. This test can increase the detection rate of Aspergillus, although it can be influenced by factors such as high-protein diets, which may cause false positives [7]. Studies suggest that the GM test is valuable for early detection of pulmonary Aspergillus infection and for assessing clinical efficacy [8]. The G test detects β-D-glucan (BDG), a component of fungal cell walls, but can be limited by factors such as prior antibiotic use, which can affect accuracy.

This study compared three common microbiological testing methods. The results showed that out of 60 patients, pathological examination identified 35 as positive and 25 as negative for pulmonary Aspergillus infection. Sputum culture identified 34 positive and 26 negative cases, with 7 false positives and 6 false negatives. The GM test identified 34 positive and 26 negative cases, with 3 false positives and 2 false negatives. The G test identified 34 positive and 26 negative cases, with 8 false positives and 7 false negatives. The GM test had higher sensitivity, specificity, accuracy, positive predictive value, and negative predictive value compared to sputum culture and the G test, with significant differences ($P < 0.05$). Thus, the GM test demonstrated superior diagnostic performance compared to the other methods and could improve clinical diagnostic accuracy.

In summary, the GM test has higher diagnostic value for pulmonary Aspergillus infection compared to sputum culture and the G test and should be considered for wider use.

References

[1] Liu, D.Y., Zeng, Q., Chen, C.H., et al. (2024). Discussion on Surgical Treatment Indications for Invasive Pulmonary Aspergillosis and Mucormycosis in Children. Chinese Journal of Thoracic and Cardiovascular Surgery, 40(2), 85-88.

[2] Song, Q., Luo, D. (2023). Analysis of the Effectiveness of Microbiological Testing for Diagnosing Pulmonary Aspergillus Infection. Contemporary Medicine Review, 21(19), 144-146.

[3] Liu, L. (2022). Exploration of the Clinical Value of Microbiological Testing for Pulmonary Aspergillus Infection. China Practical Medicine, 17(23), 90-92.

[4] Jiang, T., Tan, M., Yu, L., et al. (2024). Clinical Characteristics and Influencing Factors of Pulmonary Aspergillus Infection Complicating Acute Exacerbation in Chronic Obstructive Pulmonary Disease Patients. Chinese Journal of Hospital Infection, 34(4), 494-497.

[5] Shi, S.F. (2021). Application of Microbiological Testing in the Diagnosis of Pulmonary Aspergillus Infection. Practical Journal of Laboratory Medicine, 13(2), 77-79.

[6] Wei, Z., Rong, A.H. (2021). Diagnostic Value of Microbiological Testing for Pulmonary Aspergillus Infection. China Health Nutrition, 31(11), 1.

[7] Gui, Y.L. (2021). Analysis of the Diagnostic Value of Microbiological Testing for Pulmonary Aspergillus Infection. Pharmaceutical Frontier, 11(4), 69-70.

[8] Hu, L. (2021). Research on Microbiological Testing for Pulmonary Aspergillus Infection. China Rural Health, 13(16), 47, 49.