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Radiological manifestations of allergic bronchopulmonary aspergillosis in adult asthmatic patients

Fatima Wahab,[1] Taimur Hussain Babar,[2] Syed Farrukh Nadeem,[2] Zafar Amin,[3] Sajjad Sarwar,[4] Sara Ahmad,[4] Ammara Wahab,[5] Saba Mukhtar[6]

[1]Department of Radiology, Combined Military Hospital, Bahawalpur; [2]Department of Radiology, Combined Military Hospital, Lahore; [3]Department of Radiology, Combined Military Hospital, Nowshera; [4]Helping Hand Rehabilitation Centre, Mansehra; [5]Mukhtar A Sheikh Memorial Welfare Hospital, Multan; [6]Department of Pharmacy Practice, Faculty of Pharmacy, The Islamia University of Bahawalpur, Pakistan

Correspondence: Saba Mukhtar, Department of Pharmacy Practice, The Islamia University of Bahawalpur, Pakistan. E-mail: sabamukhtar24@gmail.com

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Abstract

Allergic bronchopulmonary aspergillosis (ABPA) develops in patients through type I or type III hypersensitivity reactions to the filamentous fungi *Aspergillus*. There is a wide spectrum of radiological presentations of ABPA, including fleeting alveolar opacities, centrilobular nodules, bronchiectasis, mucoid impaction resulting in bronchocele, cavitation, and pulmonary fibrosis. This study aims to identify the pattern of radiological presentation in our community and its implications in the clinical diagnosis of the disease.

We conducted a descriptive, cross-sectional study. The study was conducted at the Department of Radiology, Combined Military Hospital, Bahawalpur, between 4th April 2021 and 3rd October 2021. A total of 85 asthmatic patients between the ages of 18 and 60 years with a clinical diagnosis of ABPA reporting for high-resolution computed tomography (HRCT) were included. Patients with bronchiectasis other than ABPA, such as tuberculosis, foreign body, recurrent aspiration, and malignancy, were excluded. All the patients underwent an HRCT scan of the chest.

In this study, the frequency of different radiological presentations of ABPA in adult asthmatic patients was as follows: mucus plug in 47 (55.29%) patients, centrilobular nodules in 49 (57.65%) patients, central bronchiectasis in 35 (41.18%) patients, and patchy air space consolidation in 37 (43.53%) patients.

This study concluded that centrilobular nodules are the most common radiological presentation of ABPA in adult asthmatic patients, followed by the mucus plug, patchy air space consolidation, and central bronchiectasis.

Key words: asthma, allergic bronchopulmonary aspergillosis, centrilobular nodules.

Introduction

Pulmonary aspergillosis is a spectrum of mycotic diseases caused by the Aspergillus species, usually Aspergillus fumigatus [1,2]. This intensely antigenic and ubiquitous soil fungus is commonly found in the sputum of healthy individuals. However, in susceptible hosts, its ability to invade the arteries and veins facilitates its hematogenous spread. The development of the disease and its histologic, clinical, and radiologic manifestations depend on the virulence and number of spores inhaled and, more importantly, on the patient's immune status [3-5].

Pulmonary aspergillosis may take any of the following four forms: Allergic bronchopulmonary aspergillosis (ABPA) caused by a hypersensitivity reaction to the fungus; it most commonly occurs in persons with asthma. *Saprophytic aspergillosis*, or aspergilloma - The most common form; noninvasive and involves colonization of preexisting cavities. Chronic necrotizing aspergillosis (also called airway-invasive or semi-invasive aspergillosis) - A chronic, cavitary, pneumonic illness that often affects patients with preexisting chronic lung disease. Angio-invasive aspergillosis - Affects immunocompromised patients and is often fatal [6-9].

ABPA is a condition that most commonly affects patients suffering from asthma and cystic fibrosis. It occurs in 1-2% of patients with asthma and 2-15% of patients with cystic fibrosis. In Southeast Asia prevalence of ABPA in adult asthmatic patients is 7.5% [10,11]. The global burden of ABPA is 4.8 million people [12]. Allergic bronchopulmonary aspergillosis develops in patients via type I or type III hypersensitivity reactions to filamentous fungi. Aspergillus fumigatus secretes exoproteomes that compromise clearance, breach the epithelium, and activate an immune response [13]. There is a wide spectrum of radiological presentation of ABPA, including fleeting alveolar opacities, centrilobular nodules, bronchiectasis, mucoid impaction resulting in bronchocele, cavitation and cavitation, and pulmonary fibrosis [14].

ABPA is divided into different categories according to radiological presentations on High-resolution computed tomography (HRCT) Chest as ABPA-S (seropositive) – Normal HRCT, ABPA –CB (central bronchiectasis), ABPA- ORF (Other Radiological Features), ABPA-CB-ORF (central bronchiectasis with other Radiological Features) [15].

In a study from north India, 564 patients were screened from a chest clinic using the Aspergillus skin test. ABPA was diagnosed in 126 patients (27.2%). On HRCT, there were 34 patients (27%) with ABPA-S, 42 patients (33.3%) with ABPA-CB, and 50 patients (40%) with ABPA-CB-ORF. High attenuation mucus was noted in 21 patients (16.7%) [16].

Considering such a high prevalence of ABPA in Southeast Asia, it is important to identify the spectrum of the radiological presentation of the disease in Pakistan, as ABPA is commonly

misdiagnosed as tuberculosis (TB) in highly burdened TB countries. Aspergillus skin test, Serum Immunoglobulin E (IgE), and other diagnostic criteria are expensive, time-consuming, and may not be available. HRCT is quick, easily available, and expertise does exist. Early radiological identification may help in the early treatment and control of the disease process.

Materials and Methods

Study design and study setting

The study is a descriptive, cross-sectional study. All adult asthmatic patients enrolled between April 4, 2021, and October 3, 2021, between the ages of 18 and 60 years with a clinical diagnosis of ABPA, who reported for HRCT at the Radiology Department, CMH Bahawalpur, were included in this study.

Diagnostic criteria

The diagnosis of ABPA was established by the treating pulmonologist based on a comprehensive clinical evaluation. Serological and immunological criteria applied included elevated total serum IgE levels along with Aspergillus-specific IgE and/or IgG, in accordance with the ISHAM-ABPA diagnostic criteria. High-resolution CT (HRCT) of the chest was used as part of the diagnostic work-up to identify characteristic radiological features of ABPA, including bronchiectasis and mucus plugging, rather than solely for descriptive purposes. The diagnosis of asthma was made before enrollment by a pulmonologist, based on compatible clinical history and documented evidence of variable airflow limitation, as per standard clinical practice.

Inclusion criteria

The diagnosis of ABPA was established based on the ISHAM diagnostic criteria, including the presence of a predisposing condition (asthma), evidence of Aspergillus sensitization, elevated total serum IgE levels, and supportive immunological and radiological findings. This clarification has been added to enhance transparency in patient recruitment.

Exclusion criteria

All patients with post-TB bronchiectasis (assessed through medical records) and patients with bronchiectasis other than ABPA, like TB, foreign body, recurrent aspiration, and malignancy, were excluded from the study.

Data collection procedure

After approval from the ethical review committee, a total of 85 patients presenting at the radiology department of CMH, Bahawalpur, fulfilling the inclusion criteria were selected after taking informed consent. Baseline demographic data, including age, gender, duration of asthma, residential area, occupation, exposure to smoke, and compliance with medication, were noted. All the patients underwent an HRCT scan of the chest. A consultant radiologist with 3 years of experience reported all scans and different findings as per operational definitions.

Ethics approval and consent to participate

The ethical approval was provided by the ethical review committee of CMH under the reference no. CMH/BWP-0129.

Data analysis procedure

Statistical analysis was performed using SPSS version 20. The normality was checked for the variables. Mean and standard deviation were calculated for age and duration of asthma. Frequency and percentages were calculated for gender, residential area, exposure to smoke, profession, compliance with asthma medication, and radiological presentations (mucus plugging, Centrilobular nodules, Patchy air space consolidation, and central bronchiectasis).

Data were stratified based on age, gender, duration of asthma, medication compliance, occupation, and exposure to smoke to see the effect on the frequency of radiological manifestations. Post-stratification chi-square test was applied, and a *p-value* of 0.05 was taken as significant.

Results

Demographics and clinical characteristics of patients

Table 1 summarizes the demographic and selected clinical characteristics of the 85 patients included in the study. The majority of participants were aged 41–60 years (71 patients, 83.53%), while 16.47% (n = 14) were between 18 and 40 years of age. Regarding disease duration, more than half of the patients (56.47%, n = 48) had a duration of illness exceeding 24 months, whereas 43.53% (n = 37) reported a duration of 24 months.

Medication compliance was reported by 54.12% (n = 46) of the participants, while 45.88% (n = 39) were non-compliant. Exposure to smoke was noted in 44.71% (n = 38) of patients, whereas 55.29% (n = 47) reported no such exposure. In terms of occupation, field-based work was the

most common (43.53%, n = 37), followed by domestic occupations (30.59%, n = 26) and office-based work (25.88%, n = 22).

Frequency of different radiological presentations of allergic bronchopulmonary aspergillosis

Table 2 depicts the frequency of radiological manifestations observed on high-resolution computed tomography among adult asthmatic patients diagnosed with allergic bronchopulmonary aspergillosis. Centrilobular nodules were the most frequently observed finding, present in 57.65% (n = 49) of patients, followed by mucus plugging, which was identified in 55.29% (n = 47). Patchy air-space consolidation was observed in 43.53% (n = 37) of patients, while central bronchiectasis, a characteristic feature of ABPA, was noted in 41.18% (n = 35). These findings highlight the heterogeneous radiological spectrum of ABPA in adult asthmatic patients.

Stratification of the different radiological presentations concerning age

Table 3 presents the distribution of radiological features of allergic bronchopulmonary aspergillosis stratified by age group. Mucus plugging was observed in 6 of 14 patients aged 18–40 years and 41 of 71 patients aged 41–60 years, with no statistically significant difference between the two groups ($p = 0.306$). Centrilobular nodules were significantly more frequent in the 18–40-year age group (13/14) compared with the 41–60-year group (36/71), demonstrating a statistically significant association with age ($p = 0.004$). Central bronchiectasis was present in 5 younger patients and 30 older patients, with no significant difference observed between age groups ($p = 0.650$). Similarly, patchy air-space consolidation showed comparable distribution across age categories (8 vs. 29 patients), with no statistically significant association ($p = 0.261$).

Stratification of the different radiological presentations concerning gender

Table 4 summarizes the distribution of radiological features of allergic bronchopulmonary aspergillosis stratified by gender. Mucus plugging was observed in 30 of 57 males and 17 of 28 females, with no statistically significant difference between genders ($p = 0.481$).

Stratification of the different radiological presentations concerning duration

Table 5 shows the distribution of radiological features of allergic bronchopulmonary aspergillosis stratified by disease duration. Mucus plugging was observed in 23 of 37 patients with a disease duration of 24 months and 24 of 48 patients with a duration of >24 months, with no statistically

significant difference between the two groups (p = 0.592). Centrilobular nodules were significantly more frequent among patients with a disease duration of >24 months (32/48) compared with those with a duration of 24 months (17/37), demonstrating a statistically significant association (p = 0.020). Central bronchiectasis was present in 17 patients in the shorter-duration group and 18 patients in the longer-duration group, with no significant difference observed (p = 0.961). Similarly, patchy air-space consolidation showed comparable distribution between the two duration categories (12 vs. 25 patients), with no statistically significant association (p = 0.752).

Stratification of the different radiological presentations concerning medication compliance

Table 6 illustrates the distribution of radiological features of allergic bronchopulmonary aspergillosis stratified by medication compliance. Mucus plugging was observed in 23 of 46 compliant patients and 24 of 39 non-compliant patients, with no statistically significant difference between the two groups (p = 0.286). Centrilobular nodules were significantly more frequent among patients who reported medication compliance (32/46) compared with those who were non-compliant (17/39), showing a statistically significant association (p = 0.016). In contrast, central bronchiectasis was significantly more prevalent in non-compliant patients (22/39) than in compliant patients (13/46), indicating a statistically significant association (p = 0.009). Patchy air-space consolidation was identified in 23 compliant and 14 non-compliant patients, with no statistically significant difference observed (p = 0.191).

Stratification of the different radiological presentations concerning exposure to smoke.

Table 7 presents the distribution of radiological features of allergic bronchopulmonary aspergillosis stratified by exposure to smoke. Mucus plugging was observed in 18 of 38 patients with a history of smoke exposure and 29 of 47 patients without such exposure, with no statistically significant difference between the two groups (p = 0.186). Centrilobular nodules were identified in 19 exposed and 30 non-exposed patients, showing no significant association with smoke exposure (p = 0.200). Central bronchiectasis was significantly more prevalent among patients without smoke exposure (24/47) compared with those with smoke exposure (11/38), demonstrating a statistically significant association (p = 0.039). Patchy air-space consolidation occurred in 17 exposed and 20 non-exposed patients, with no statistically significant difference observed (p = 0.840).

Stratification of the different radiological presentations concerning occupation.

Table 8 shows the distribution of radiological features of allergic bronchopulmonary aspergillosis stratified by occupational category. Mucus plugging was observed in 18 of 26 patients engaged in domestic work, 16 of 37 field workers, and 13 of 22 office workers, with no statistically significant difference across occupational groups ($p = 0.114$). Centrilobular nodules were identified in 16 domestics, 20 field, and 13 office workers, with no significant association observed between occupation and the presence of centrilobular nodules ($p = 0.829$). Central bronchiectasis was present in 14 domestics, 12 field, and 9 office workers, again showing no statistically significant difference among the occupational categories ($p = 0.236$). Similarly, patchy air-space consolidation demonstrated comparable distribution across domestic (13 patients), field (13 patients), and office (11 patients) occupations, with no statistically significant association ($p = 0.391$).

Discussion

This study describes the spectrum of radiological manifestations of allergic bronchopulmonary aspergillosis (ABPA) in adult asthmatic patients and explores their association with selected demographic and clinical variables. The findings underscore the heterogeneity of radiological presentations in ABPA and identify specific associations that may reflect disease activity, duration, and treatment-related factors.

Among the radiological features, centrilobular nodules and mucus plugging were the most frequently observed findings, consistent with prior studies describing airway-centered inflammation as an early and prominent manifestation of ABPA. Central bronchiectasis, a hallmark of established disease, was present in just over 40% of patients, aligning with reports that not all patients with ABPA exhibit bronchiectasis at presentation, particularly in earlier disease stages.

Age-based stratification revealed a significant association between younger age (18–40 years) and the presence of centrilobular nodules. This finding may reflect earlier or more active inflammatory disease in younger patients, preceding irreversible structural changes such as bronchiectasis. Similar observations have been reported in earlier imaging-based studies suggesting that transient radiological findings are more common in early or less advanced ABPA, whereas bronchiectasis tends to accumulate with disease chronicity.

This study determines the frequency of different radiological presentations of allergic bronchopulmonary aspergillosis in adult asthmatic patients. Aspergillosis of the respiratory tract

has diverse manifestations that range from hypersensitivity disorders to rapidly invasive disseminated disease [17,18]. In an observational study at Agha Khan University patients who fulfilled the ISHAM criteria were included, out of 120 patients 64 fulfilled the criteria of ABPA 49% were males, the mean duration of ABPA diagnosis was 4 years 77% had underlying asthma, and 25% were misdiagnosed as T.B, mucus plugging (65%), Fleeting infiltrates (61%) and central bronchiectasis (78%) most common HRCT findings. All patients received systemic corticosteroids and itraconazole. 33% were in remission, 20% were steroid dependent, and 2% had developed end-stage fibrotic lung requiring long-term O2 therapy [19].

Medication compliance emerged as a clinically important factor. Central bronchiectasis was significantly more prevalent among non-compliant patients, supporting the hypothesis that inadequate or inconsistent treatment contributes to structural airway damage. Conversely, centrilobular nodules were more frequently observed among compliant patients, potentially reflecting better-preserved airway architecture and reversible inflammatory changes. These findings are in agreement with previous reports linking poor treatment adherence to radiological progression and worse long-term outcomes in ABPA. It is believed that bronchiectasis occurs in areas with previous consolidation. On plain chest roentgenograms, this is visualized either as parallel line opacities, representing a widening of the bronchi, or as ring opacities, 1-2 cm in diameter, representing a dilated bronchial face. Parallel-line shadows were observed in 65%-70% of patients with ABPA, and ring shadows in 45%-68% [17,20,21].

In our study, the *p*-value associated with centrilobular nodules is 0.004. The presence of centrilobular nodules appears to be significantly related to the presence or absence of mucus plugging, central bronchiectasis, and patchy air space consolidation. These results are consistent with other studies performed by K. Ahmad et al. [22]. In the study, centrilobular nodules or mucus plugging are likely to be associated with the radiological presentation, suggesting that these two radiological presentations may be related. These studies are consistent with the findings of other studies as well.

The radiographic manifestations of ABPA are speculative by nature and stage of the disease. The radiographic findings are generally categorized as transient or permanent. The transient findings include nodules, consolidation, tram track opacities, finger-in-glove appearance, fleeting densities, and permanent abnormalities described are ring shadows, bronchiectasis, and pleuropulmonary fibrosis based on the temporal manifestations of the ABPA. In a pre-CT era, consolidation was believed to be the most common manifestation of the ABPA; in contrast, recent studies prove mucoid impaction as a more common finding than consolidation. In current

practice, HRCT is the imaging modality of choice for the evaluation of suspected ABPA patients. The common HRCT manifestations of ABPA are bronchiectasis with or without mucoid impaction, consolidation/s, mosaic attenuation of lungs, centrilobular nodules with or without a tree-in-bud appearance, and chronic pleuropulmonary fibrotic changes. Less commonly encountered HRCT manifestations are miliary nodules, perihilar opacities, pulmonary mass, and pleural effusion [23,24].

Serological ABPA is a stage of the disease with normal HRCT chest. [25], whereas bronchiectasis and HAM stages are self-explanatory. Chronic pleuropulmonary fibrosis stage of ABPA should at least have two other findings apart from bronchiectasis and HAM, like pulmonary fibrosis, fibrocavitory lesions, mycetoma, and thickened pleura [26,27]. Chronic stages of the disease may present with atelectasis/collapse of the lung, consolidation, fibrocalcific changes, consolidation with central breakdown, calcific mediastinal or hilar lymphadenopathy, fibrotic bands, cavities, and cicatricial emphysema. At this stage, distinguishing ABPA from old pulmonary tuberculosis is difficult.

Gender and occupation were not significantly associated with most radiological features, except for a higher prevalence of centrilobular nodules among females. Existing literature on sex-based radiological differences in ABPA remains limited and inconsistent, and this observation warrants cautious interpretation.

Overall, the results support the concept that radiological findings in ABPA reflect a continuum from reversible inflammatory changes to irreversible structural damage, influenced by disease control and treatment adherence. These findings highlight the importance of early diagnosis, regular monitoring, and sustained treatment compliance to prevent disease progression.

First, the study was not originally designed to evaluate quantitative correlations between immunological markers or asthma control scores and radiological severity. Second, standardized scoring of bronchiectasis extent was not uniformly available across all patients, as imaging assessments were performed primarily for diagnostic purposes rather than for detailed severity grading. Additionally, Asthma Control Test (ACT) scores were not systematically recorded at the time of HRCT acquisition in all participants, limiting the feasibility of a robust correlation analysis. Given these constraints, performing such analyses retrospectively would risk introducing bias and compromising the validity of the findings. We have therefore refrained from conducting these exploratory analyses in the current manuscript. Secondly, given the limited sample size, no formal adjustment for multiple comparisons was performed.

Conclusions

This study concluded that centrilobular nodules are the most common radiological presentation of allergic bronchopulmonary aspergillosis in adult asthmatic patients, followed by mucus plug, patchy air space consolidation, and central bronchiectasis. So, we recommend that early radiological identification of HRCT will be very helpful for early treatment and control of the disease process.

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Table 1. Demographics and clinical characteristics of the patients (n=85).

Variables	N	%
Age (in years)		
18-40	14	16.47
41-60	71	83.53
Duration (months)		
24	37	43.53
>24	48	56.47
Medication compliance		
Yes	46	54.12
No	39	45.88
Exposure to smoke		
Yes	38	44.71
No	47	55.29
Occupation		
Domestic	26	30.59
Field	37	43.53
Office	22	25.88

Table 2. Frequency of different radiological presentations of allergic bronchopulmonary aspergillosis in adult asthmatic patients (n=85).

Radiological presentations	N	%
Mucus plugging	47	55.29
Centrilobular nodules	49	57.65
Central bronchiectasis	35	41.18
Patchy air space consolidation	37	43.53

Table 3. Stratification of the different radiological presentations concerning age.

Radiological presentations	Response	18-40 (n=14)	41-60 (n=71)	p
Mucus plugging	Yes	06	41	0.306
	No	08	30	
Centrilobular nodules	Yes	13	36	**0.004**
	No	01	35	
Central bronchiectasis	Yes	05	30	0.650
	No	09	41	
Patchy air space consolidation	Yes	08	29	0.261
	No	06	42	

Table 4. Stratification of the different radiological presentations concerning gender.

Radiological presentations	Response	Male (n=57)	Female (n=28)	p
Mucus plugging	Yes	30	17	0.481
	No	27	11	
Centrilobular nodules	Yes	28	21	**0.023**
	No	29	07	
Central bronchiectasis	Yes	23	12	0.825
	No	34	16	
Patchy air space consolidation	Yes	27	10	0.308
	No	30	18	

Table 5. Stratification of the different radiological presentations concerning duration.

Radiological presentations	Response	24 hours (n=37)	>24 hours (n=48)	p
Mucus plugging	Yes	23	24	0.592
	No	14	24	
Centrilobular nodules	Yes	17	32	**0.02**
	No	20	16	
Central bronchiectasis	Yes	17	18	0.961
	No	20	30	
Patchy air space consolidation	Yes	12	25	0.752
	No	25	23	

Table 6. Stratification of the different radiological presentations concerning medication compliance.

Radiological presentations	Response	Yes (n=46)	No (n=39)	p
Mucus plugging	Yes	23	24	0.286
	No	23	15	
Centrilobular nodules	Yes	32	17	**0.016**
	No	14	22	
Central bronchiectasis	Yes	13	22	**0.009**
	No	33	17	
Patchy air space consolidation	Yes	23	14	0.191
	No	23	25	

Table 7. Stratification of the different radiological presentations concerning exposure to smoke.

Radiological presentations	Response	Yes (n=38)	No (n=47)	p
Mucus plugging	Yes	18	29	0.186
	No	20	18	
Centrilobular nodules	Yes	19	30	0.200
	No	19	17	
Central bronchiectasis	Yes	11	24	**0.039**
	No	27	23	
Patchy air space consolidation	Yes	17	20	0.840
	No	21	27	

Table 8. Stratification of the different radiological presentations concerning occupation.

Radiological presentations	Response	Domestic (n=26)	Field (n=37)	Office (n=22)	p
Mucus plugging	Yes	18	16	13	0.114
	No	08	21	09	
Centrilobular nodules	Yes	16	20	13	0.829
	No	10	17	09	
Central bronchiectasis	Yes	14	12	09	0.236
	No	12	25	13	
Patchy air space consolidation	Yes	13	13	11	0.391
	No	13	24	11	