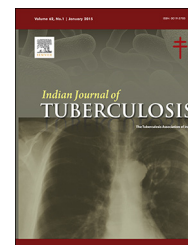


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Original article

Prevalence of allergic bronchopulmonary aspergillosis in asthmatic patients: A prospective institutional study

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ABSTRACT

Background: Allergic bronchopulmonary aspergillosis (ABPA) is characterized by an allergic inflammatory response to colonization by *Aspergillus* species, most commonly *Aspergillus fumigatus*.**Aim:** To study the prevalence of ABPA in asthmatic patients presenting to our institute.**Materials and methods:** All consecutive asthma patients attending our allergy clinic Out Patient Department (OPD) over a period of 20 months were tested with skin prick test (SPT) for *Aspergillus* antigens and those who were found positive were further evaluated for ABPA using Greenberger's criteria.**Results:** Seventy consecutive asthmatic patients were screened by SPT using *Aspergillus* antigens. Thirteen patients (18.57%) were found to be SPT positive, out of which nine patients (12.9%) were diagnosed as having ABPA using Greenberger's criteria. ABPA was common among 25–35 age group with no gender predilection. ABPA patients had longer duration of illness, predominantly mixed pattern in PFT, higher mean absolute eosinophil count (AEC) and serum total IgE compared to non-ABPA asthmatic patients. Specific IgE for *A. fumigatus* was positive in all ABPA patients and serum precipitins were positive in seven patients (77.58%). Chest X-ray abnormalities were seen in five patients (55.6%) and HRCT showed central bronchiectasis in eight patients (88.9%) with varying other radiological features. None were sputum fungal culture positive and five patients (55.6%) have been misdiagnosed as pulmonary tuberculosis in the past.

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Conclusion: The prevalence of ABPA is significantly higher in bronchial asthma patients presenting to tertiary care centers and hence awareness is required among physicians for early diagnosis and management of ABPA to achieve better asthma control and to avoid permanent lung damage.

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1. Introduction

Allergic bronchopulmonary aspergillosis (ABPA) is a hypersensitivity mediated pulmonary disease characterized by an allergic inflammatory response to colonization of the airways by *Aspergillus* species, most commonly *Aspergillus fumigatus*.¹ ABPA usually occurs in patients of bronchial asthma and cystic fibrosis with a variety of clinical and radiological manifestations.

The first three cases of ABPA were reported by Hinson et al. in 1952 in England.² The first case of ABPA in the United States was reported in 1968, and the first childhood case of ABPA in the United States was reported by Slavin et al. in 1970.^{3,4} In India, ABPA was first reported by Shah in 1971.⁵ Data on childhood ABPA from India are very few.^{6,7} The youngest case in India was first reported in 2006 by Gaur et al. where the patient was only four years old.⁸ In 2017, Mathur et al. reported a case of ABPA in a child aged four years and nine days.⁹

The prevalence of ABPA is approximately 1–2% in asthmatics, 7–14% in corticosteroid-dependent asthmatics, and 1–15% in those with cystic fibrosis.^{10–13} There is no gender predilection noted. Denning et al. estimated the prevalence of ABPA in adults with asthma to be 2.5% (range 0.72–3.5%) and concluded that the global burden of ABPA potentially exceeds 4.8 million people.¹⁴ In India, several studies show a prevalence of 7–27.2% among asthmatic patients.^{15–19}

2. Materials and methods

All consecutive patients of bronchial asthma between 15 and 55 years of age irrespective of sex, race and religion, attending the out-patient department of Allergy clinic, National Institute of Tuberculosis and Respiratory Diseases (NITRD), New Delhi over a period of 21 months (September, 2014 to May, 2016) were enrolled in this study. Approval for the study was obtained from our institute's research and ethical committees. Informed consent was obtained from patients enrolled in the study. Pregnant and lactating women, patients with history of smoking, patients with major medical illness were excluded.

132 bronchial asthma suspects were referred to our Allergy clinic. On the basis of inclusion and exclusion criteria and the consent to participate in the study a total of 70 patients were included in to the study as initial diagnosis of bronchial asthma diagnosed as per Global Initiative for Asthma (GINA) guidelines.

All enrolled subjects were screened by skin prick test (SPT) using purified extracts of *A. fumigatus*, *Aspergillus flavus*, *Aspergillus niger*, *Aspergillus versicolor*, *Aspergillus tamaris* obtained from All Cure Pharma Pvt. Ltd. Grading of SPT was

done as per Shivpuri's classification. Those who showed positive reaction to any *Aspergillus* antigen in SPT were further evaluated for ABPA using Greenberger's criteria²⁰ (Table 1).

Patients with all five major criteria were considered to have ABPA-CB (ABPA with central bronchiectasis). The presence of all major criteria in the absence of central bronchiectasis were considered ABPA-S (seropositive ABPA). Minor criteria were not used to diagnose ABPA rather was only used as a supportive for the diagnosis of ABPA.

Serum total IgE was quantitatively measured using ELISA technique manufactured by CALBIOTECH™ and a value of <200 IU/mL was considered normal. Serum precipitins for *Aspergillus* was done using PLATELIA™ *Aspergillus* IgG kit. ImmunoCAP® FEIA method was used to determine the specific IgE for *A. fumigatus* and levels >0.35 kUA/L was considered positive. Blood eosinophil counts greater than 500 cells/mm³ was considered eosinophilia.

Wherever possible old chest radiographs of the patients were reviewed to look for any fleeting opacities, evidence suggestive of bronchiectasis, fibrosis, mucus plugging, consolidation. High resolution computerized tomography (HRCT) was done to look for central bronchiectasis and other radiological features.

3. Statistical analysis

SPSS version 21 was used for statistical analysis. Percentages were compared by Fisher's exact test and Means by Student's t-tests. *p*-value <0.05 was considered significant.

4. Results

Out of 70 asthmatic patients enrolled in the study, thirteen patients (18.57%) showed positive SPT for one or more *Aspergillus* antigen(s), out of which nine patients (12.9%) turned out to be ABPA and the remaining four patients did not fulfill the major criteria set for diagnosis of ABPA. Thus, the prevalence of ABPA among bronchial asthma patients is estimated to be 12.9% (CI 6.9–22.7%).

Table 2 summarizes the characteristics of the non-ABPA asthmatic patients and ABPA patients. Out of 9 ABPA patients in the study, seven patients (77.8%) were males, two patients (22.2%) were females and their age ranged from 25 to 52 years with a mean age of 35.33 ± 11 years. This is not statistically significant compared to non-ABPA asthmatic patients (*p* 0.202). The mean duration of illness was higher among ABPA patients compared to non-ABPA asthmatic patients and it was statistically significant (18.44 years vs 8.8 years, *p* 0.001).

Table 1 – Greenberger's criteria.²⁰

Major criteria
(1) Asthma
(2) Central bronchiectasis on a computed tomography (CT)
(3) Immediate cutaneous reactivity to <i>Aspergillus</i> species
(4) Elevated total serum IgE (>417 IU/mL or >1000 ng/mL)
(5) Elevated specific serum IgE and/or IgG to <i>Aspergillus fumigatus</i>
Minor criteria
(1) Chest roentgenographic infiltrates
(2) Peripheral blood eosinophilia
(3) Serum precipitating antibodies to <i>Aspergillus fumigatus</i>
(4) Mucous plugs
(5) Sputum culture positive for <i>Aspergillus</i> species

Among all *Aspergillus* antigen SPT positive patients in this study ($n = 13$), *A. fumigatus* and *A. tamarii* antigens were positive in 10 patients (76.92%) each. *A. flavus* and *A. versicolor* were positive in four patients (30.76%) each, and *A. niger* was positive in three patients (23%).

Among diagnosed ABPA patients ($n = 9$), along with *A. fumigatus* SPT positivity, *A. tamarii* antigen was also positive in seven patients (77.8%), *A. versicolor* and *A. flavus* were positive in four patients (44.4%) each, *A. niger* was positive in three patients (33.3%) (Tables 3 and 4).

The mean absolute eosinophil count (AEC) was significantly elevated in ABPA patients compared to non-ABPA asthmatic patients (1078.89 vs 552.79 cells/mm³, $p < 0.001$). Among ABPA patients, the mean serum total IgE was 871.37 IU/mL compared to 623.88 IU/mL among non-ABPA asthma group. But the difference was not statistically significant ($p = 0.118$). Serum

specific IgE to *A. fumigatus* was positive in all nine ABPA patients and serum precipitins were positive in seven ABPA patients (77.8%).

Chest X-ray findings were present in five out of nine ABPA patients (55.6%). Two patients had areas of consolidation of varying sizes, three patients had irregular infiltrations in various lung zones. In HRCT, central bronchiectasis was the most common finding seen in eight out of nine diagnosed ABPA cases (88.9%). HRCT chest showed no abnormality in one patient (11.1%, ABPA-S), only bronchiectasis in two patients (22.2%, ABPA-CB), and bronchiectasis along with other radiological findings in six patients (66.7%, Allergic Bronchopulmonary Aspergillosis with Central Bronchiectasis and Other Radiological Features, ABPA-CB-ORF). Other radiological findings seen in CT chest apart from bronchiectasis were centrilobular opacities, mucus plugs, calcification, consolidation, mediastinal lymphadenopathy and fibrosis.

The mean Forced Expiratory Volume in 1 second (FEV1) was 2.19 ± 0.62 among ABPA patients. Seven (77.8%) out of nine ABPA patients in our study had mixed pattern. Six patients (66.7%) had moderate to very severe impairment. Out of nine diagnosed ABPA patients in this study, none grew any *Aspergillus* sp. whereas in non-ABPA asthma group two patients had growth in fungal culture. One patient's sputum grew *A. fumigatus* and the other grew *A. flavus*. Five ABPA patients (55.6%) had received anti-tubercular treatment (ATT) in the past compared to only six patients (9.84%) in the non-ABPA asthma group. This difference is statistically significant ($p = 0.003$).

5. Discussion

Majority of ABPA patients in our study belonged to 25–45 years (mean, 35.33 years) with no sex predilection. The mean age ranged from 31.2 to 36.25 years in several studies.^{15,18,21–23} Although ABPA can occur at any age, majority of the cases are seen in 20–40 years of age, ABPA has also been reported in children^{7,24} and even in infants.²⁵

In our study, ABPA patients had significantly longer mean duration of illness compared to non-ABPA asthmatic patients, which was statistically significant (18.44 years vs 8.8 years, $p = 0.001$). Similar observation was made in various studies.^{18,21,23,26,27} Whether long standing asthma leads to the colonization of *A. fumigatus* and subsequent development of ABPA or the development ABPA leads to chronicity of asthma is debatable.

More than half of the ABPA patients ($n = 5$, 55.56%) in our study had received ATT in the past, sometimes more than once compared to only 6 patients (9.84%) among non-ABPA asthmatic patients. In India, several studies have reported that ABPA was misdiagnosed as pulmonary tuberculosis in as many as 17–58% of cases.^{15,26,28,29} This may be due factors such as radiological similarities and lack of awareness among healthcare professionals.

Spirometry usually show an obstructive pattern of varying severity in ABPA patients with or without a restrictive pattern and reduction in DL_{CO}.³⁰ In long standing ABPA cases with extensive bronchiectasis and parenchymal fibrosis, an irreversible mixed pattern and a reduced diffusion capacity is usually seen.³¹ Seven (77.8%) ABPA patients in our study

Table 2 – Characteristics of non-ABPA asthma patients and ABPA patients.

Parameters	Non-ABPA asthma group ($n = 61$)	ABPA group ($n = 9$)	p value
Age (years)			
Mean $\pm$ SD	30.31 $\pm$ 10.9	35.33 $\pm$ 11	0.202
Range	15–53	25–52	
Sex			
Males	42 (68.86%)	7 (77.78%)	0.714
Females	19 (31.14%)	2 (22.22%)	
Duration of illness (years)			
Mean $\pm$ SD	8.8 $\pm$ 7	18.44 $\pm$ 10.32	0.001
Range	1–25	5–35	
Anti-tubercular treatment			
H/O ATT	6 (9.84%)	5 (55.56%)	0.003
FEV1			
Mean $\pm$ SD	1.99 $\pm$ 0.8	2.19 $\pm$ 0.62	0.505
Range	0.38–3.93	0.98–2.94	
% Pred FEV1			
Mean $\pm$ SD	63.57 $\pm$ 19.71	62.67 $\pm$ 16.16	0.816
Range	15–92	33–78	
AEC (cells/mm ³)			
Mean $\pm$ SD	552.79 $\pm$ 368.32	1078.89 $\pm$ 457.7	<0.001
Range	20–1760	520–1830	
Total IgE (IU/mL)			
Mean $\pm$ SD	623.88 $\pm$ 448.22	871.37 $\pm$ 343.86	0.118
Range	65.67–2651	434–1441	

p -Value <0.05 was considered significant.

Table 3 – Frequency of different *Aspergillus* antigen positivity by SPT.

Antigen	Total patients (n = 13) Frequency (%)	ABPA patients (n = 9) Frequency (%)	Patients not fulfilling the criteria (n = 4) Frequency (%)
<i>A. fumigatus</i>	10 (76.92)	9 (100)	1 (25)
<i>A. tamarii</i>	10 (76.92)	7 (77.8)	3 (75)
<i>A. versicolor</i>	4 (30.76)	4 (44.4)	
<i>A. niger</i>	3 (23)	3 (33.3)	
<i>A. flavus</i>	4 (30.76)	4 (44.4)	

Table 4 – *Aspergillus* antigen sensitization pattern by SPT among ABPA patients.

No. of patients (n = 9)	<i>Aspergillus</i> SPT positivity
4	<i>A. fumigatus</i> , <i>A. tamarii</i>
1	<i>A. fumigatus</i> , <i>A. flavus</i>
1	<i>A. fumigatus</i> , <i>A. tamarii</i> , <i>A. versicolor</i> , <i>A. niger</i>
1	<i>A. fumigatus</i> , <i>A. tamarii</i> , <i>A. versicolor</i> , <i>A. flavus</i>
1	<i>A. fumigatus</i> , <i>A. flavus</i> , <i>A. versicolor</i> , <i>A. niger</i>
1	<i>A. fumigatus</i> , <i>A. tamarii</i> , <i>A. flavus</i> , <i>A. versicolor</i> , <i>A. niger</i>

showed mixed obstruction and restrictive pattern with moderate to severe impairment in lung function. *A. fumigatus* is the most common fungus causing severe asthma associated with fungal sensitivity (SAFS).³² All four patients with moderate to severe obstruction have long standing symptom for 20–25 years, while only 2 patients out of five patients with mild obstruction have symptoms for 23–35 years. However, the development of ABPA is not dependent on severity of asthma but the development of ABPA leads to chronic asthma and increased severity of pre-existing asthma.³³ Hence all patients of asthma must be screened for risk of development of ABPA by SPT for *Aspergillus*.

In our study, the AEC was significantly elevated in ABPA patients ($p < 0.001$). Many studies have reported significantly elevated AEC among ABPA patients compared to non-ABPA patients.^{16,18,21,23,34,35} But absolute eosinophil count has neither proved to be sensitive nor specific for the diagnosis of ABPA. Further AEC can vary based on the stage of ABPA, intake of oral corticosteroids or spontaneously.³⁰ AEC can be used as a supportive parameter in the diagnosis of ABPA provided medications like corticosteroids and other conditions common in tropical countries like tropical pulmonary eosinophilia (TPE) has been ruled out.

Among ABPA patients, the mean serum total IgE was 871.37 IU/mL compared to 623.88 IU/mL among non-ABPA asthma group ($p = 0.118$). Total serum IgE may be mildly elevated in allergic asthma but it is markedly elevated in ABPA with levels typically exceeding greater than >417 IU/mL (1000 ng/mL). Similar to AEC, serum total IgE is neither sensitive nor specific for the diagnosis of ABPA as levels vary based on the stage of ABPA, intake of oral corticosteroids.

In this study, serum precipitins for *A. fumigatus* were positive in seven ABPA patients (77.8%) compared to only two patients (3.3%) in non-ABPA asthma group. This difference is

statistically significant ($p < 0.001$). Results similar to our study were obtained in the several studies.^{15,21,29}

In ABPA, the rates of culture positivity range from 39% to 60% depending on the number of specimens examined.^{34,36} In our study none of the ABPA patients had any growth on fungal culture. This may be due to a small sample size of the study. Culture of *A. fumigatus* in sputum is supportive but not diagnostic of ABPA because the fungus can also be grown in other pulmonary diseases due to ubiquitous nature of the fungi.

Four patients who were SPT positive for *Aspergillus* antigens were not considered as having ABPA, due to not meeting the adopted criteria in this study. However, two of these patients, who were SPT positive for *A. tamarii* only, met all the criteria including central bronchiectasis but were negative for specific IgE against *A. fumigatus*, which is obvious. Further, specific IgE for *A. tamarii* is not available commercially. Such cases can be considered as having ABPA due to “*Aspergillus* species other than *A. fumigatus*” or “atypical ABPA” based on clinical and radiological features. For instance, there are two case reports which reported ABPA due to *A. niger* without bronchial asthma.^{37,38}

6. Conclusion

ABPA is commonly seen in young age group, with no gender predilection. Any patient of long standing, poorly controlled bronchial asthma, with markedly elevated peripheral eosinophil counts, fleeting shadows/pulmonary infiltrates on serial chest radiographs should always be screened with *Aspergillus* skin testing and/or serum total IgE to rule out the possibility of ABPA.

A diagnosis of ABPA should not be excluded based only on the cut off values of total serum IgE as it is highly variable depending on stage of ABPA, intake of oral corticosteroids. In these cases, ABPA should be confirmed by serum specific IgE for *A. fumigatus* and HRCT. ABPA is commonly misdiagnosed as pulmonary tuberculosis in India due to the radiological similarity which delays the diagnosis of ABPA.

Currently, no uniform diagnostic criteria and diagnostic algorithm are followed for diagnosis of ABPA in India. Further studies are required to simplify the diagnosis and treatment algorithms in resource limited countries like India.

7. Limitations

Sample size of this study was small. This is an institutional study so results may be different from population based study.

As all of the asthmatic patients attending general OPD were not referred to our allergy clinic OPD, this study may not reflect true prevalence of ABPA and it may even be higher in the asthmatic patients attending our institute.

Conflicts of interest

The authors have none to declare.

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