“Allergic Bronchopulmonary Aspergillosis: Radiological and Microbiological Profile of Patients Presented in an Outpatient Pulmonary Clinic of a Developing Country”.

Nousheen Iqbal (✉ nousheen.iqbal@aku.edu)
Aga Khan University Hospital  https://orcid.org/0000-0001-5026-9874

Muhammad Irfan
Aga Khan University Hospital

Mustafa bin Ali Zuabairi
dow university of health and sciences

Maaha Ayub
Aga Khan University Medical College Pakistan

Safia Awan
Aga Khan University

Kausar Jabeen
Aga Khan University Hospital

Ali Zuabairi
Aga Khan University Hospital

Research

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Abstract

Background:

There is limited data available about allergic bronchopulmonary aspergillosis (ABPA) from Pakistan. The aim of the study was to describe the radiological and microbiological profile of ABPA patients presenting to outpatient pulmonary clinic of a tertiary care hospital, Karachi, Pakistan.

Methods

A retrospective study was conducted on ABPA patients who presented to pulmonary outpatient clinic, Aga Khan University Hospital, Karachi, Pakistan from January 2017 to December 2018. Data was collected on microbiology and radiology features on predesigned proforma.

Results

A total 7759 asthmatic patients presented at outpatient pulmonology clinic during study period. Of the 245 patients labeled as ABPA, 167 patients fulfilled the inclusion criteria and 91 (54.5%) were female (mean age 41.9 ± 13.0 years). High resolution CT scan (HRCT) chest was available in 126 patients. Of these, 104 (82.5%) patients had bronchiectasis. Central bronchiectasis was noted in 98 (94.2%), mucus plugging in 71 (56.3%) and hyperinflation was seen in 30 (23.4%) patients. Microbiological testing was available in 103/167 (61.7%) patients. The most common bacterial pathogen was *Pseudomonas aeruginosa* 32 (31.1%) followed by *Hemophilus influenzae* 16 (15.5%) and *Moraxella catarrhalis* 7 (9.7%). *Aspergillus fumigatus* 17 (23.6%) was the most common mold followed by *Aspergillus flavus* 16 (22.2%) and *Aspergillus niger* 11 (15.3%). Co infection (bacterial and fungal) was found in 18 (17.45%) patients.

Conclusion

Bronchiectasis was frequently observed in our cohort of patients with ABPA. *Pseudomonas aeruginosa* was found to be common among bacterial pathogens. Isolation of fungus is not uncommon in these patients.

Background

Allergic bronchopulmonary aspergillosis (ABPA) is a hypersensitivity disease caused by an immunological reaction to the *Aspergillus* species, with *Aspergillus fumigatus* being the most commonly implicated pathogen [1]. The occurrence of ABPA is commonly seen among asthma and cystic fibrosis patients with a prevalence of 12.9% and 8.9% respectively [1].

ABPA is generally diagnosed via a combination of clinical, serological and radiographic findings [2, 3, 4]. Previous [2, 3] diagnostic criteria has been modified by the international society of Human and animal mycology (ISHAM) [4] since APBA may be present without bronchiectasis and all criteria previously proposed are not required to establish the diagnosis of ABPA. Radiological findings of ABPA vary and
include, fleeting pulmonary infiltrates, centrilobular nodules characterizing dilated and opacified bronchioles, bronchiectasis and mucoid impaction leading to bronchocoele formation (the finger in glove sign) [5]. ABPA is often misdiagnosed as tuberculosis (TB) or pneumonia, due to similar radiological presentations [6, 7], leading to a considerable delay in the provision of appropriate treatment especially in a TB endemic country like Pakistan.

Clinically ABPA is divided into five stages, stage I with acute flare while stage V is advanced fibrotic disease. It is further classified into two categories, according to Patterson et al, namely ABPA-S called seropositive only in the absence of bronchiectasis and ABPA-CB (central bronchiectasis) if bronchiectasis is present. ABPA-CB is the more aggravated form of the disease [8].

A Japanese study [9] found isolation of Aspergillus spp. in sputum in 59% patients, including A. fumigatus (33%), A. niger (6%), A. terreus (4%), unspecified Aspergillus spp. (16%) and Schizophyllum commune was identified in 6%. Sputum microscopy and culture was positive in 63% of patients in Indian study [10] but overall data is limited on microbiology for both fungi and bacterial pathogens among patients with ABPA. However, the most frequently isolated organisms reported in patients with non-cystic fibrosis CF bronchiectasis are Haemophilus influenzae, Pseudomonas aeruginosa, and Moraxella catarrhalis while Pseudomonas aeruginosa was reported with more advanced bronchiectasis. [11]

Another complication of ABPA is development of chronic pulmonary aspergillosis (CPA), which has an estimated burden of 411,000 patients, out of 4,837,000 ABPA patients. CPA is associated with significant morbidities, including potentially fatal hemoptysis [12].

A study estimates that, annually, 1661 cases of ABPA develop in the Pakistani population [13] but data on radiological and microbiological profile of these patients are very limited. The objective of this study is to determine the microbiological and radiographic profile of ABPA patients. We believe that an understanding of radiological and microbiological patterns among ABPA patients in a TB endemic country, may considerably improve diagnosis and prognosis in these patients.

Methods

This retrospective study was conducted on patients diagnosed to have ABPA at the adult outpatient pulmonary clinic of Aga Khan University Hospital, (AKUH) Karachi, Pakistan from January 2017 to December 2018. AKUH is the one of the largest tertiary care facilities of Karachi with 650-beds, and largest outpatient department that receives patients from wide socio-economic backgrounds from all over the city and outside from different cities of Pakistan as well. The study was approved by the Ethical Review Committee of Aga Khan University Hospital.

The patients of ABPA were initially identified through outpatient pulmonary clinic database. Medical records of all patients who were labelled as ABPA in database were reviewed. Those patients who fulfilled the inclusion criteria were then recruited for study. The inclusion criteria for ABPS was adopted from ISHAM 2013 [4] and included: 1) Age ≥ 18 years with underlying asthma, 2) Serum IgE level ≥ 1000 IU/ml,
A total of 7759 asthmatic patients presented at outpatient pulmonology clinic during study period, 245 (3.15%) were labeled as ABPA and 167 /245(68.16%) patients fulfilled the inclusion criteria. The mean age of patients was 41.9 ±13.0 years, and 91 (54.5%) were females. All patients had a long-standing history of asthma with a mean duration of 17.7 ± 13.1 years before they were diagnosed with ABPA. Out of 167 patients, 104 (62.3%) patients had ABPA-CB and 63/167 (37.2%) had ABPA-S. All five stages of ABPA were observed among the patients and 87 (52.1%) had stage 3. Cough (78.4%), dyspnea (56.9%), wheezing (25.1%), chest pain (25.1%) and hemoptysis (18.6%) were the predominant presenting symptoms at clinic. All patients received systemic and inhaled corticosteroids while 135 (80.8%) patients were on itraconazole (Table 1).

The radiographic images available for these patients included chest X-ray in 167/167 (100%) and high-resolution CT (HRCT) in 126/167 (75.44%). Table 2 describes the radiological pattern of study population. Bilateral involvement on X-rays was found in 84.4%. The common X-ray findings were hyperinflation 91 (54.5%) and fleeting infiltrations 84 (50.3%). HRCT was available for 126/167 (75.44%) patients, with bilateral involvement in 92% and bronchiectasis being the most commonly observed finding present in 104/126 (82.5%) patients (Table 2).

Sputum culture results were available in 103 (61.7%) patients with bacterial growth in 66 (64.1%) of the cases. The microbiological profile is presented in (Table 3). The common pathogens identified were Pseudomonas aeruginosa (31.1%) and Hemophilus influenzae (15.5%). One or more fungi were isolated

### Statistical Analysis

SPSS V.19.0 was used for data analysis. Descriptive statistics were done, and results are presented as mean and standard deviation for continuous variable and number and percentages for categorical variables. Number and percentages were reported of all radiological and microbiological features of patients with ABPA.

### Results

A total of 7759 asthmatic patients presented at outpatient pulmonology clinic during study period, 245 (3.15%) were labeled as ABPA and 167 /245(68.16%) patients fulfilled the inclusion criteria. The mean age of patients was 41.9 ±13.0 years, and 91 (54.5%) were females. All patients had a long-standing history of asthma with a mean duration of 17.7 ± 13.1 years before they were diagnosed with ABPA. Out of 167 patients, 104 (62.3%) patients had ABPA-CB and 63/167 (37.2%) had ABPA-S. All five stages of ABPA were observed among the patients and 87 (52.1%) had stage 3. Cough (78.4%), dyspnea (56.9%), wheezing (25.1%), chest pain (25.1%) and hemoptysis (18.6%) were the predominant presenting symptoms at clinic. All patients received systemic and inhaled corticosteroids while 135 (80.8%) patients were on itraconazole (Table 1).

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Aspergillus fumigatus (23.6%) followed by Aspergillus flavus (22.2%) were commonly isolated fungi. A fungal-bacterial co-infection was seen in 18 patients. Microorganisms isolation are more common in ABPA-CB (n=81/103, 78.64%) as compared to ABPA-S (n=22/103, 21.36%). Among the bacterial pathogens, a greater percentage of patients with Pseudomonas aeruginosa (33.3%) and Hemophilus influenzae (17.2%) were isolated from ABPA-CB than with ABPA-S while Hemophilus parainfluenzae (9%) and Klebsiella pneumonia (18.8%) were frequently isolated with ABPA-S.

Discussion

This is the first study from Pakistan that has highlighted radiographic and the microbiological features associated with ABPA. We have found hyperinflation on chest X-ray and central bronchiectasis on HRCT to be the most common radiological findings. Microbiologically, we found Pseudomonas aeruginosa to be the most common bacterial infection among ABPA-CB patients. Isolation of fungi, such as Aspergillus fumigatus was also seen in patients with ABPA.

In our study, more patients had ABPA-CB than ABPA-S which is in concordance with an another study conducted in India [14]. On radiological evaluation, bilateral chest x-ray and HRCT observations were noted in 84.4% and 92.1% of the patients respectively. The most common of the HRCT observation was bronchiectasis which was seen in 77.8% of the patients. This observation was found to be consistent with similar studies carried out in China and India, which also reported bronchiectasis as the most common observation [15,16]. Agarwal et al [15] reported 36.6% of patients with a normal HRCT whereas in our study none of the patients had normal HRCT this may be due to delayed diagnosis leading to advanced disease or referral bias of a tertiary care hospital. Additionally, patients with minimal disease did not undergo HRCT chest as usually at our center, HRCT is performed when underlying parenchymal abnormality is suspected. On the other hand, study from China [16] reported mucus plugging as a common radiographic finding, among many other observations, similar to our study. However, hyperinflation was not reported. The study also described the presenting clinical symptoms of cough, dyspnea, sputum, wheezing, chest pain, fever and hemoptysis in the diagnosed patients consistent with our study.

To the best of our knowledge, there have been very limited data available on chest X-ray findings associated with ABPA, except for an article which states that during early stages, chest X-ray images are usually normal or mimicking asthma [5]. In our study, X-ray showed fleeting filtrations and hyperinflation to be present in more than half of the patients while lung consolidations, cavitation, fibrosis, nodules and cystic changes were also seen.

Laboratory testing showed an increase in mean serum IgE which was comparable with published data [17]. Normally a blood eosinophil level >1000 cells/mm³ is used as a diagnostic criterion [18]. However, 25% of ABPA patients are also reported to have an absolute eosinophil count of <500 cells/mm³ [17], which may possibly be attributed to the use of drugs prior to diagnosis which may have reduced blood
eosinophil levels. In our study, we measured the differential eosinophil count which was found to have a mean value of $11.2 \pm 7.7\%$.

The concept of the five stages of ABPA was first proposed by Patterson et al\textsuperscript{[19]}. The fibrotic stage represents the most advanced stage of the disease with complications and a poor disease prognosis. It has been reported by Greenberger et al\textsuperscript{[20]} that patients frequently present in stage 3 or the exacerbation stage of the disease which is characterized by the presence of chest infiltrates on radiography. Furthermore, the same study\textsuperscript{[20]} reported that the total serum IgE concentration in stage 3 patients is normally two times as high as the baseline IgE levels, while in the remainder of the stages the IgE levels may be elevated or even normal. More than half (52%) of our patients were also presented in stage 3 of the disease, while 50% of the patients were seen to have fleeting infiltrates on radiography. The total mean serum IgE levels in our study were elevated most likely because the majority of the patients were in stage 3 of ABPA.

The fungal isolation in ABPA is known to act as both the infecting organism as well as an allergen, both of which are responsible for eliciting the symptoms of ABPA\textsuperscript{[21]}. These allergens lead to an immune response only in already immunocompromised patients. Furthermore, fungal hyphae are responsible for the release of chemicals which further trigger the secretion of mediators such as certain interleukins and cytokines and inflammatory cells, including eosinophils\textsuperscript{[17]}.

Aspergillus species have been previously reported in other studies like Shah et al\textsuperscript{[22]} to be a major cause for ABPA, however data on bacterial spectrum in ABPA patients is not available.

**Limitations**

A few limitations of our study included (1) the small sample size that was taken into account and the fact that the ABPA patients from only one tertiary care hospital were included which might have created a referral bias in our results. Therefore, we suggest for a large-scale study involving multiple hospitals throughout the country to be conducted. (2) HRCT chest was not done in all patients and was only done where suspicious of bronchiectasis was high so may be percentage of bronchiectasis is under reported. (3) We did not use Aspergillus skin test or precipitating and IgG antibodies to Aspergillus in all of our patients due to limited availability.

**Conclusion**

Hyperinflation and fleeting infiltrates on chest X-rays and bronchiectasis on HRCT was the most common radiological finding in our ABPA patients. *Pseudomonas aeruginosa* and *A. fumigatus* was identified as a most common bacterial and fungal pathogens isolated respectively on sputum samples during exacerbation particularly with ABPA-CB. We suggest that both radiographic evaluation and microbiological profile should be identify early to reduce the extent of lung damage.

**Abbreviations**
Allergic bronchopulmonary aspergillosis (ABPA)

High resolution CT scan (HRCT)

The international society of Human and animal mycology (ISHAM)

Tuberculosis (TB)

Allergic bronchopulmonary aspergillosis seropositive only in the absence of bronchiectasis (ABPA-S)

Allergic bronchopulmonary aspergillosis with central bronchiectasis (ABPA-CB)

Aga Khan University Hospital (AKUH)

Declarations

- **Ethics approval and consent to participate**
  The study was approved by the ethical review board of Aga Khan University Hospital. It’s a retrospective chart review study so no consent was required.

- **Consent for publication**: Not applicable

- **Availability of data and materials**
The datasets used and/or analyzed during the current study are available from the corresponding author on reasonable request.

- **Competing interests**: None to declare

- **Funding**: None

- **Authors’ contributions**

  **NI** has made contributions in has made contributions to conception and design, interpretation of data, drafting the manuscript and revising it critically for important intellectual content.

  **MI** has made contributions in conception and design, interpretation of data, drafting the manuscript and revising it critically for important intellectual content.

  **MBAZ** has made contributions to conception and design, interpretation of data, drafting the manuscript and revising it critically for important intellectual content.

  **MA** has made contributions in conception and design, interpretation of data, drafting the manuscript and revising it critically for important intellectual content.

  **SA** has made a contribution in statistical analysis and interpretation of data.

  **KJ** has made contributions in conception and design, interpretation of data, drafting the manuscript and revising it critically for important intellectual content.
ABSZ has made contributions in conception and design and revising it critically for important intellectual content.

All authors read and approved the final manuscript.

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Tables
Table 1
Characteristics of study population (n = 167)

| Variables                | n (%)       |
|--------------------------|-------------|
| Age, in years            | 41.9 ± 13.0 |
| Gender                   |             |
| Male                     | 76 (45.5)   |
| Female                   | 91 (54.5)   |
| Duration of Asthma       | 17.7 ± 13.1 |
| Duration of ABPA,        | 4.8 ± 5.0   |
| ABPA                     | 63 (37.2)   |
| ABPA-S*                  |             |
| ABPA-CB*                 | 104 (62.3)  |
| Stage of ABPA            |             |
| 1                        | 15 (9.0)    |
| 2                        | 39 (23.4)   |
| 3                        | 87 (52.1)   |
| 4                        | 24 (14.4)   |
| 5                        | 2 (1.2)     |
| Mean Serum IgE %         | 2455 ± 1600.3 |
| Mean Eosinophil count    | 11.2 ± 7.7  |
| Smoking status           |             |
| Current                  | 1 (0.6)     |
| Non-smoker               | 159 (95.2)  |
| Ex-smoker                | 7 (4.2)     |

**Symptoms**

**ABPA-S** = allergic bronchopulmonary aspergillosis seropositive, **ABPA-CB** = allergic bronchopulmonary aspergillosis central bronchiectasis
| Variables                        | n (%)          |
|---------------------------------|----------------|
| Cough                           | 131 (78.4)     |
| Dyspnea                         | 95 (56.9)      |
| Wheezing                        | 42 (25.1)      |
| Chest pain                      | 42 (25.1)      |
| Fever                           | 37 (22.2)      |
| Weight loss                     | 36 (21.6)      |
| Hemoptysis                      | 31 (18.6)      |
| Pallet of sputum                | 31 (18.6)      |
| Exacerbation in 12 months       | 120 (71.9)     |
| Treatment:                      |                |
| Itraconazole                    | 135 (80.8)     |
| Systemic Steroids               | 167 (100)      |

**ABPA-S** = allergic bronchopulmonary aspergillosis seropositive, **ABPA-CB** = allergic bronchopulmonary aspergillosis central bronchiectasis
| Variables                        | n (%)          |
|---------------------------------|----------------|
| **Chest X-ray; n = 167/167**    |                |
| Unilateral                      | 26 (15.6)      |
| Bilateral                       | 141 (84.4)     |
| Consolidation                   | 29 (17.4)      |
| Nodules                         | 47 (28.1)      |
| Cavitation                      | 22 (13.2)      |
| Fleeting filtration             | 84 (50.3)      |
| Fibrosis                        | 16 (9.6)       |
| Hyperinflation                  | 91 (54.5)      |
| Cystic changes                  | 47 (28.1)      |
| **HRCT; n = 126/167**           |                |
| Unilateral                      | 10 (7.9)       |
| Bilateral                       | 116 (92.1)     |
| Bronchiectasis                  | 104 (82.5)     |
| Central Bronchiectasis          | 98/104 (77.8)  |
| Non Central Bronchiectasis      | 6/104 (4.7)    |
| Mucus plugging                  | 71 (56.3)      |
| Hyperinflation/emphysema        | 30 (23.8)      |
| Tree in bud Appearance          | 12 (9.5%)      |
| Consolidation                   | 11 (8.7%)      |
| Collapse                        | 11 (8.7%)      |
| Fibrosis                        | 7 (5.5%)       |
| Aspergilloma                    | 7 (5.5%)       |
Table 3
Microbiological features in patients with ABPA

| Sputum culture available | 103/167 (61.7%) |
|-------------------------|-----------------|
| **Bacteria isolated**   |                 |
| *Pseudomonas aeruginosa*| 32 (31.1)       |
| *Haemophilus influenzae*| 16 (15.5)       |
| *Haemophilus parainfluenzae* | 3 (2.9)     |
| *Klebsiella pneumoniae* | 8 (7.8)         |
| *Moraxella catarrhalis* | 7 (9.7)         |
| **Fungi isolated**      |                 |
| *Aspergillus fumigatus* | 17 (23.6)       |
| *Aspergillus niger*     | 11 (15.3)       |
| *Aspergillus flavus*    | 16 (22.2)       |
| *Aspergillus terreus*   | 2 (2.8)         |
| **Fungal bacterial co-infection** | 18 (17.5) |
| **Organisms identified**|                 |
| ABPA-S (n = 22/103)     |                 |
| ABPA-CB (n = 81/103)    |                 |
| *Pseudomonas aeruginosa*| 5 (22.7%)       |
| *Haemophilus influenzae*| 2 (9.0%)        |
| *Haemophilus parainfluenzae* | 2 (9.0%) |
| *Klebsiella pneumoniae* | 4 (18.8%)       |
| *Moraxella catarrhalis* | 0               |
| *Aspergillus fumigatus* | 1 (4.5%)        |
| *Aspergillus niger*     | 4 (18.8%)       |
| *Aspergillus flavus*    | 5 (22.7%)       |
| *Aspergillus terreus*   | 1 (4.5%)        |

**ABPA-S** = allergic bronchopulmonary aspergillosis seropositive, **ABPA-CB** = allergic bronchopulmonary aspergillosis central bronchiectasis