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ORIGINAL ARTICLE

# Chest radiographic and computed tomographic manifestations in allergic bronchopulmonary aspergillosis

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## Abstract

**AIM:** To investigate the chest radiographic and high resolution computed tomography (HRCT) chest manifestations in glucocorticoid-naïve allergic bronchopulmonary aspergillosis (ABPA) patients.

**METHODS:** This is a prospective observational study and includes 60 consecutive glucocorticoid-naïve patients with ABPA who underwent chest radiography and HRCT of the chest (1.25 mm every 10 mm) in the routine diagnostic workup for ABPA.

**RESULTS:** Chest radiographs were normal in 50% of cases. Of the remainder, most patients demonstrated permanent findings in the form of parallel line and ring shadows suggesting bronchiectasis. Consolidation was detected in 17 cases but in the majority, the corresponding HRCT chest scan showed mucus-filled bronchiectatic cavities. Chest HRCT was normal in 22 patients, while central bronchiectasis (CB) was demonstrated in the remaining 38 patients. Bronchiectasis extended to the periphery in 33%-43% depending on the criteria used for defining CB. The other findings observed on HRCT were mucoid impaction, centrilobular nodules and high-attenuation mucus in decreasing order of frequency.

**CONCLUSION:** Patients with ABPA can present with normal HRCT chest scans. Central bronchiectasis cannot be considered a characteristic feature of ABPA as peripheral bronchiectasis is commonly observed. Consolidation is an uncommon finding in ABPA.



**Key words:** Allergic bronchopulmonary aspergillosis; Chest radiograph; High resolution computed tomography; Computed tomography; *Aspergillus*

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## INTRODUCTION

Allergic bronchopulmonary aspergillosis (ABPA) is a complex pulmonary disorder caused by immune reactions to antigens that are released by *Aspergillus fumigatus* (*A. fumigatus*), a ubiquitous fungus that colonizes the tracheobronchial tree of patients with asthma and cystic fibro-

sis[1]. The disease can complicate the course in 2%-32% of asthmatics[2], and 2%-15% of patients with cystic fibrosis[3]. Patients most commonly present with poorly controlled asthma although hemoptysis, expectoration of mucus plugs, malaise and fever are also encountered[4]. The diagnosis is made on a combination of clinical, immunological and radiological findings using the Rosenberg-Patterson criteria or a modification thereof[5,6]. The natural history of ABPA is variable, and is characterized by recurrent remissions and relapses. In many patients it causes progression from mild asthma to glucocorticoid-dependent asthma, while in others, chronic lung damage in the form of central bronchiectasis (CB) or pulmonary fibrosis may ensue.

High resolution computed tomography (HRCT) of the chest is the radiological investigation of choice in patients with ABPA[7]. Chest radiography is not sufficiently sensitive to detect the presence or the extent of bronchiectasis[8]. Bronchography, traditionally considered the investigation of choice for the diagnosis of bronchiectasis, is not only invasive but may also be associated with adverse effects[9]. HRCT of the chest safely allows detection of abnormalities not apparent on chest radiography with a sensitivity and specificity of 96%-98% and 93%-99% respectively, compared to bronchography in diagnosis of bronchiectasis[10,11]. The chest radiographic findings depend on the clinical stage of the disease. Transient and fleeting opacities are characteristically found during acute exacerbations of the disease, whereas fixed abnormalities are encountered in later stages of the disease. The findings on HRCT chest scan include CB, mucus plugging with bronchocele formation, centrilobular nodules and others[12].

Few studies have reported HRCT chest findings in patients with ABPA[13-22]. Most of these studies have focused their attention on detection of CB rather than describing the CT findings. In fact, only two studies have described the occurrence of centrilobular nodules in ABPA[20,22]. Moreover, with time, change in disease epidemiology and better understanding of the disease, the radiological manifestations may be different from those originally described. For example, high-attenuation mucus has been a recently described radiological finding in ABPA. In this study, we describe the chest radiographic and HRCT chest manifestations in glucocorticoid-naïve patients with ABPA diagnosed in the Chest Clinic of a tertiary care hospital in North India. Further, we have also performed a systematic review of all the studies describing the HRCT chest manifestations of ABPA.

## MATERIALS AND METHODS

This is a prospective observational study, and includes consecutive glucocorticoid-naïve patients with ABPA diagnosed in the Chest Clinic of this institute over a period of 9 mo (January 2009 to September 2009). An informed consent was taken from all patients, and the study was approved by the Local Ethics Committee. In our Chest Clinic, all patients with asthma are screened for *Aspergillus* sensitization using an intradermal skin test. Patients who demonstrate immediate cutaneous hyperreactivity to *Aspergillus* skin test are further evaluated with: IgE levels (total and *A. fumigatus*-specific), total eosinophil count, *Aspergillus* precipitins and HRCT of the chest. Patients are classified as having ABPA if they meet the following two criteria: (1) total IgE levels > 1000 IU/mL; and (2) *A. fumigatus*-specific IgE levels > 0.35 kUA/L; and two of the following criteria: (1) presence of serum precipitins against *A. fumigatus*; (2) radiographic pulmonary opacities (fixed/transient); (3) eosinophil count > 1000 cells/μL in peripheral blood; and (4) CB on HRCT chest[6,22-24]. All the investigations, including CT scan, are done prior to starting glucocorticoid therapy.

*Aspergillus* skin test is performed by injecting the test forearm intradermally with 0.2 mL of the *Aspergillus* antigen (100 PNU/mL)[25]. The reactions are classified as type Ⅰ, if wheal and erythema occurs within a minute and resolves within 1 to 2 h. Any amount of subcutaneous edema after 6 h is classified as type Ⅲ reaction.

Serum total IgE and *A. fumigatus*-specific IgE levels were assayed with commercially available kits using the quantitative enzyme-linked immunosorbent assay (Demeditec diagnostics GmbH, Kiel, Germany) and the fluorescent enzyme immunoassay (UniCap Systems; Pharmacia Upjohn; Stockholm, Sweden).

*A. fumigatus* precipitins were detected by the Ouchterlony's gel diffusion techniques as described by Longbottom and Pepys[26].

The total leucocyte count was initially determined using an auto-analyzer (LH-750 or SF-3000). The percentage of differential leucocyte count was ascertained by counting and classifying 100 white blood cells on a peripheral blood smear. The total eosinophil count was obtained by multiplying the percentage with the total leucocyte count.

Spirometry was performed on a dry rolling seal spirometer (Spiroflow; PK Morgan Ltd.; Kent, UK) to determine the lung function measurements and bronchodilator reversibility. Age, gender, height and spirometry data were recorded for all patients using computer software previously developed by us[27].

Chest radiography was performed in all patients. The radiographic findings were characterized as transient or fixed as described by McCarthy *et al*[28] with minor modifications. Transient opacities include consolidation, band-like shadows (toothpaste opacities, appearance of a "V", inverted "V" or a "Y" shaped shadow), finger-in-glove opacities (ovoid perihilar shadows with an expanded rounded distal end), circular shadows, and atelectasis. Fixed changes include parallel line or tram line shadows (width of the zone between the lines is more than that of a normal bronchus) and ring shadows.

HRCT of the chest was performed on a 16-row, multiple detector CT scanner (LightSpeed Plus; GE Medical

**Table 1 Baseline characteristics of 60 patients with allergic bronchopulmonary aspergillosis *n* (%)**

| | |
|---|---|
| Demographic details | |
| Age (yr), median (IQR) | 30 (21.3-43.5) |
| Sex (M:F) | 34:26 |
| History | |
| Duration of asthma (yr), median (IQR) | 6.5 (3-10.75) |
| Hemoptysis | 20 (33.3) |
| Expectoration of brownish-black mucus plugs | 23 (38.3) |
| Prescription of anti-tuberculous therapy | 17 (28.3) |
| Tobacco smoking | 3 (5) |
| Spirometry | |
| Normal | 14 (23.3) |
| Mild obstruction | 15 (25) |
| Moderate obstruction | 19 (31.7) |
| Severe obstruction | 12 (20) |
| Bronchodilator reversibility | 29 (48.3) |
| Immunological findings | |
| Aspergillus skin test | |
| Type 1 | 60 (100) |
| Type 3 | 47 (78.3) |
| Absolute eosinophil count (/μL), median (IQR) | 800 (485-1535) |
| Aspergillus precipitins | 50 (83.3) |
| IgE levels (total) (IU/mL), median (IQR) | 6068.5 (3041-10284) |
| IgE levels (*Af*) (kU/L), median (IQR) | 6.5 (1.31-23.23) |

Systems; Slough, UK) with a 512 matrix size. The scans [120 kilovolts; 10 mA; window width, 1500 Hounsfield units (HU); and window level, -600 HU] were obtained with a scan time of three seconds in the supine position at full end-inspiration from lung apex to base. The image acquisition was spaced and the images (1.25 mm at 10-mm intervals) were reconstructed using the high-spatial-frequency algorithm. The scans were analyzed at the lobar as well as segmental level. Individual bronchopulmonary segments were identified by their relationship to the major and minor fissures, and the appropriate lobar bronchi[29]. The lobes were classified as three on the right and two on the left with lingular lobe considered as part of the left upper lobe. We divided the right lung into 10 segments, and left into 8 segments according to the classification of Jackson and Huber[30]. All scans were assessed for radiological abnormalities and were categorized as follows: (1) normal bronchi were those having the lumen diameter similar to the adjacent artery. A bronchus was considered to be dilated if the bronchoarterial ratio (internal diameter of the bronchi divided by the external diameter of its accompanying artery) was more than one[31]. Bronchiectasis was further classified as cylindrical, varicose or cystic. Cylindrical bronchiectasis, the mildest form of this disease, appears as tram track or signet ring depending on the orientation of bronchi relative to the scan plane. Varicose bronchiectasis was considered to be moderate dilatation of the bronchus with irregular bronchial walls showing a beaded appearance. Cystic bronchiectasis was defined as marked saccular dilatation, which appears as a cluster of air-filled cysts[32]; (2) CB was defined using two different criteria, depending on whether the bronchiectasis was confined to the medial half (point midway between hilum and chest wall) or the medial two-thirds of the lung[33]; (3) the presence of high attenuation mucus (HAM) was considered if the mucus was visually denser than the paraspinal skeletal muscle[23,34,35]; (4) centrilobular nodules were considered to be present if the nodules were distributed primarily within the center of the secondary pulmonary lobule with or without a tree-in-bud pattern[36]; (5) presence of parenchymal abnormalities including consolidation, parenchymal scarring, bullae, atelectasis and pneumothorax were also noted. The criteria used to define these appearances were as described by Webb *et al*[31]; and (6) patients were classified radiologically as ABPA-S, ABPA-CB and ABPA-CB-HAM based on the presence or absence of CB and HAM[35].

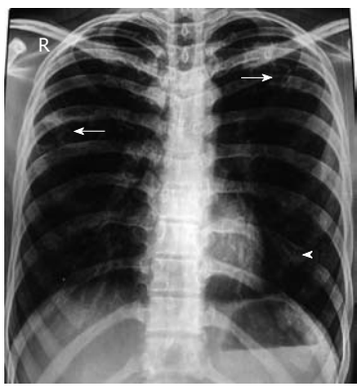


**Figure 1 Chest radiograph showing ring opacities (arrows) and parallel line shadows (arrowhead).**

## RESULTS

During the study period, 60 patients [34 men, 26 women; median (IQR) age, 30 years (21.3-43.5)] were diagnosed with ABPA. The median duration of asthma prior to diagnosis of ABPA was 6.5 mo. The baseline demographic, clinical, spirometric, and immunological findings are shown in Table 1. Almost 29% of the patients had received anti-tuberculous therapy inappropriately prior to diagnosis of ABPA. Spirometry was normal in 23.3% and bronchodilator reversibility could be demonstrated in almost half of the patients.

### *Radiographic findings on the initial chest radiograph*

The chest radiograph was normal in 50% of cases (Table 2). Of the remaining patients, the majority had permanent findings on the chest radiograph in the form of parallel line and ring shadows (Figure 1). Consolidation was detected in 17 (28.3%) cases. However, in 13 of them, the corresponding CT showed mucus-filled bronchiectatic cavities (Figure 2A and B), while classic consolidation was observed in both chest radiograph and chest CT in four patients (Figure 2C and D). Other findings observed were toothpaste opacities (Figure 4A), fleeting pulmonary

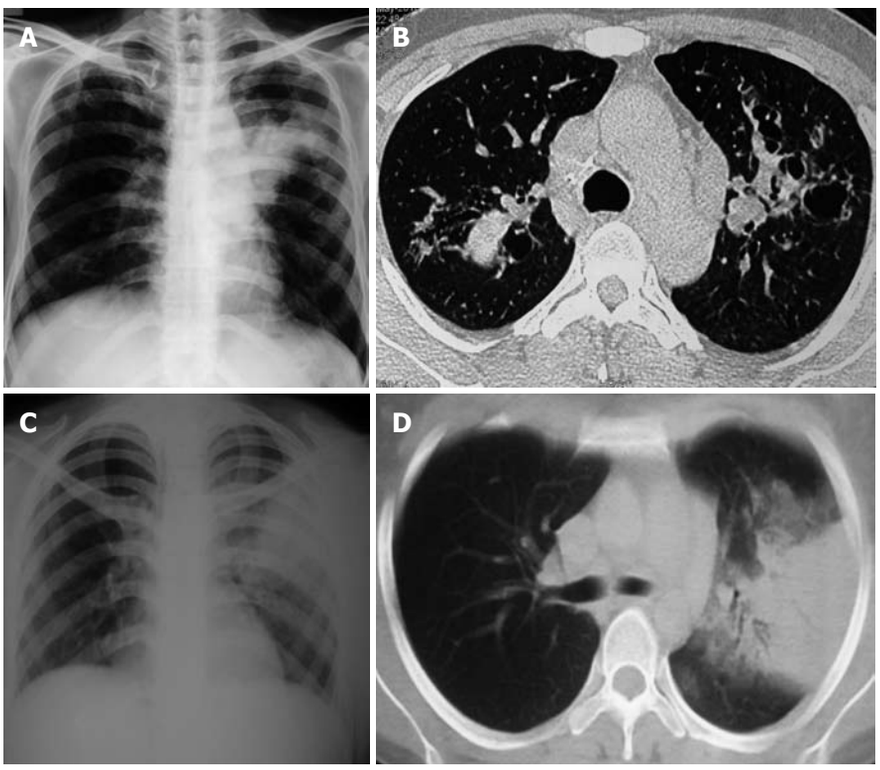


**Figure 2 Chest radiograph.** A, B: Chest radiograph (right panel) demonstrating consolidation in the left upper zone. Corresponding high resolution computed tomography of the chest (left panel) shows mucus-filled dilated bronchi; C, D: Chest radiograph (right panel) demonstrating consolidation in left upper zone. Computed tomography chest (left panel) shows typical consolidation with air bronchograms.

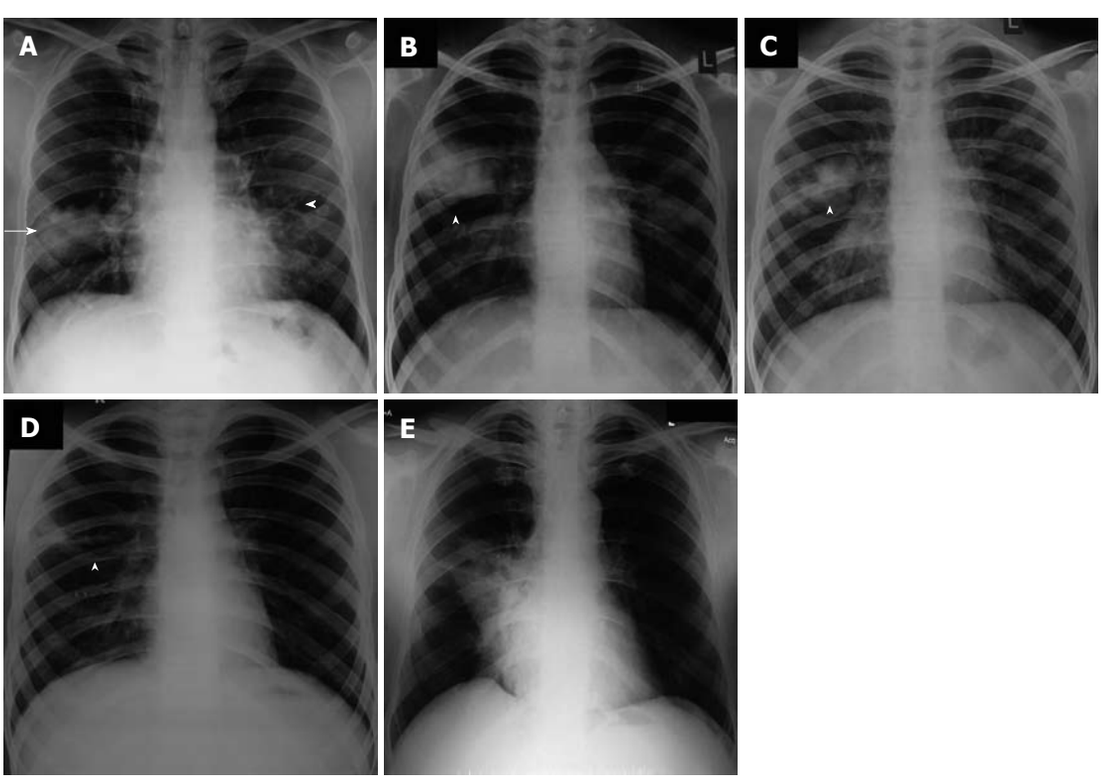


**Figure 3 Chest radiograph**. A: Chest radiograph showing consolidation (arrow) and tram track opacities (arrowhead); B-D: Chest radiographs performed over time in a patient with allergic bronchopulmonary aspergillosis showing fleeting pulmonary opacities, and clearance after treatment. Arrowheads depict the fleeting opacities; E: Chest radiograph showing subsegmental collapse.

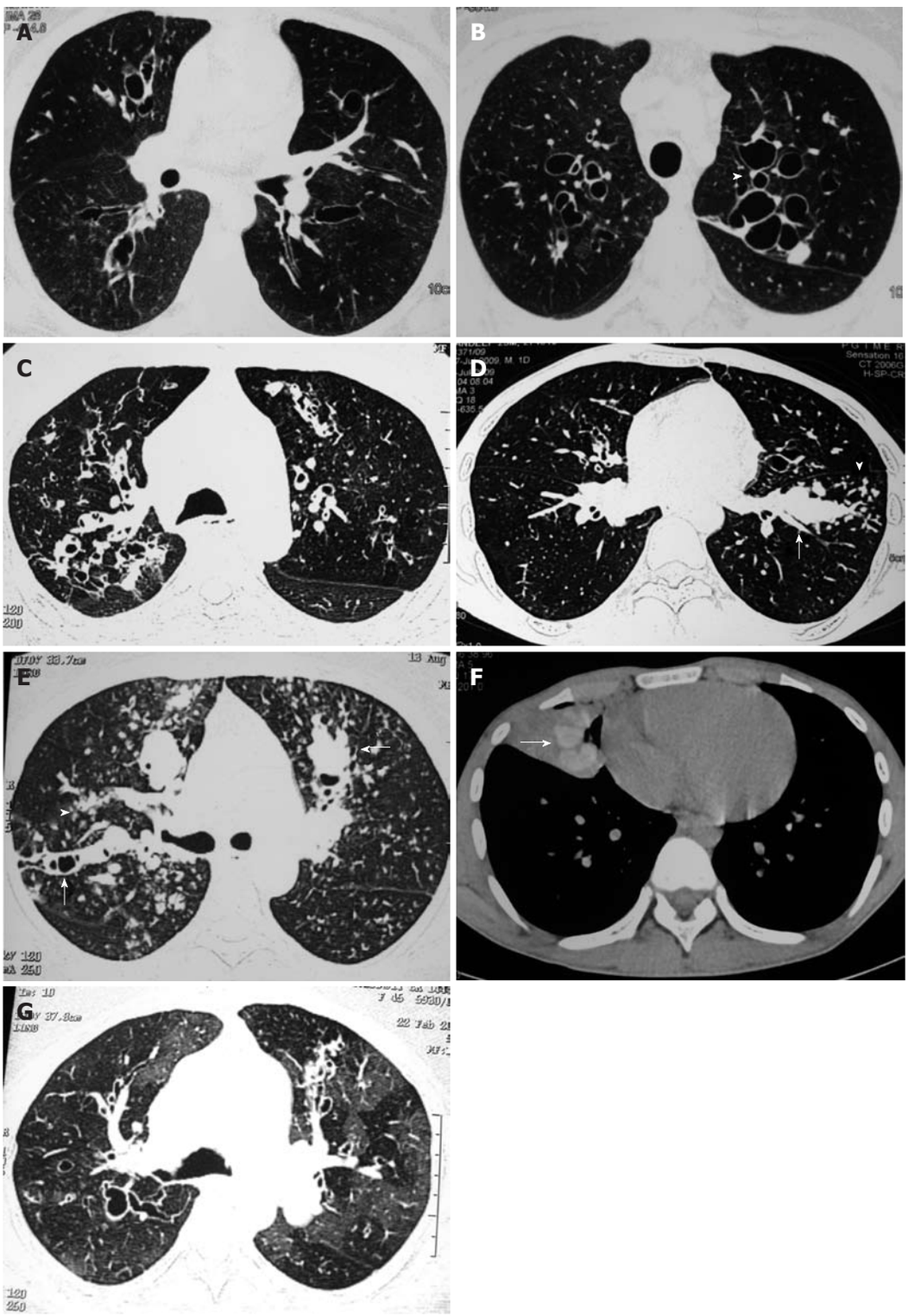


**Figure 4 High resolution computed tomography chest scan**. A, B: High resolution computed tomography chest scan showing typical central bronchiectasis. The upper panel shows cylindrical bronchiectasis while the lower panel shows cystic bronchiectasis; C: High resolution computed tomography chest scan showing bronchiectasis extending to the periphery. Also seen are mosaic attenuation and centrilobular nodules; D, E: High resolution computed tomography chest scan demonstrating mucus plugging of dilated bronchi (arrows) with evidence of centrilobular nodules in a tree-in-bud fashion (arrowheads); G: High resolution computed tomography chest scan showing central bronchiectasis with extensive areas of mosaic attenuation.

opacities (Figure 3B-D) and atelectasis (Figure 3E).

### *HRCT chest findings*

HRCT of the chest was normal in 22 patients, while CB was demonstrated in the remaining 38 patients (Figure 4A and B). Eight patients with normal chest radiographs were found to have CB on HRCT chest scan while all patients with abnormal chest radiographs had CB on chest CT.

**Table 2 Radiographic findings in the first chest radiograph in 60 cases of allergic bronchopulmonary aspergillosis**

| | |
|---|---|
| Normal | 30 |
| Transient | |
| Fleeting opacities | 24 |
| Toothpaste/finger-in-glove opacities | 23 |
| Consolidation | 17 |
| Nodular | 13 |
| Atelectasis | 8 |
| Fixed | |
| Parallel line and ring shadows | 25[1] |
| Cystic bronchiectasis | 10 |

[1]Includes tramline shadows.

Bronchiectasis was generally extensive with the median number of lobes and segments involved being 4 and 7, respectively. The details of lobes and segments involved with regard to CB are shown in Table 3. Of the 300 lobes and 1080 segments, 22 patients (110 lobes, 396 segments) had normal HRCT, whereas 8 lobes and 20 segments could not be evaluated due to the presence of collapse or fibrosis. Of the remaining 182 lobes and 664 segments, 139 lobes and 282 segments were involved by CB. Cylindrical, varicose and cystic bronchiectasis was observed in 37, 73 and 29 lobes, respectively. While there was no predilection for any particular lobe or segment, the posterior segment of the right upper lobe had CB involvement in the bulk of cases. Three patients had isolated lower lobe bronchiectasis without involvement of the upper lobes. Bronchiectasis extended to the periphery (Figure 4C) in 33%-43% depending on the criteria used for defining CB (Table 3). Other findings noted in decreasing order of frequency were mucoid impaction, centrilobular nodules (Figure 4D and E), high-attenuation mucus (Figure 4F) and mosaic attenuation (Figure 4G).

**Table 3 High resolution computed tomography findings in 60 consecutive patients with allergic bronchopulmonary aspergillosis *n* (%)**

| | Results |
|---|---|
| Staging of ABPA | |
| ABPA-S | 22 (36.7) |
| ABPA-CB | 25 (41.7) |
| ABPA-CB-HAM | 13 (21.7) |
| Lobar and segmental involvement by bronchiectasis ($n$ = 38), median (IQR) | |
| Number of lobes | 4 (3-5) |
| Number of segments | 7 (4-9) |
| No. of lobes/segments not evaluable | 8/20 |
| No. of lobes/segments affected by central bronchiectasis | 139/182 |
| No. of lobes affected by peripheral bronchiectasis | |
| By 1/2 criteria | 60/139 (43.2%) |
| By 2/3 criteria | 46/139 (33.1%) |
| Right upper lobe | 33/38 |
| Apical segment | 14 |
| Anterior segment | 19 |
| Posterior segment | 25 |
| Right middle lobe | 23/38 |
| Medial segment | 21 |
| Lateral segment | 13 |
| Right lower lobe | 27/38 |
| Apical | 20 |
| Medial | 10 |
| Anterior | 12 |
| Lateral | 15 |
| Posterior | 14 |
| Left upper lobe | 27/38 |
| Apicoposterior | 17 |
| Anterior | 17 |
| Superior lingular | 15 |
| Inferior lingular | 9 |
| Left lower lobe | 29/38 |
| Apical | 19 |
| Anterior | 12 |
| Lateral | 12 |
| Posterior | 18 |
| Other findings | |
| Centrilobular nodules and tree-in-bud opacities | 28 (46.7) |
| Atelectasis | 8 (13.3) |
| Mucoid impaction | 30 (50) |
| Mosaic attenuation | 12 (20) |
| High-attenuation mucus | 13 (21.7) |
| Lower lobe involvement without upper lobe involvement | 3 (5) |

ABPA: Allergic bronchopulmonary aspergillosis; CB: Central bronchiectasis; HAM: High attenuation mucus.

## DISCUSSION

ABPA was first described by Hinson *et al*[37] in 1952 from the United Kingdom in a description of pyrexial illness occurring in asthmatics characterized by recurrent episodes of consolidation with peripheral blood eosinophilia. This was followed by reports of ABPA from other continents[38-40]. The disease was initially considered to be rare until large series were published from different countries[41,42]. In a genetically susceptible individual, inhaled conidia of *A. fumigatus* are able to germinate into hyphae, releasing antigens that not only compromise mucociliary clearance and breach the airway epithelial barrier, but also activate the immune system of the lung[3]. This leads to influx of inflammatory cells with resultant tissue injury and the characteristic finding of CB. The finding of proximal bronchiectasis, i.e., involvement of segmental and subsegmental bronchi with sparing of the distal branches, is believed to be typical of ABPA[43].

The current study represents one of the largest reporting radiological manifestations of ABPA. The importance of chest radiographic findings is currently questionable with the advent of HRCT of the chest, and the radiographic manifestations seem to have lost their diagnostic importance. The most common chest radiographic finding noted in our study was a normal radiograph. Although transient findings were commonly observed in those with chest radiographic abnormality, most of the patients also had fixed abnormality indicating the presence of permanent lung damage. Consolidation, considered to be the most frequent chest radiographic abnormality of ABPA[28], was evident on chest radiograph in our study. The HRCT chest scan, however, revealed

**Table 4 Studies describing high resolution computed tomography findings in patients with allergic bronchopulmonary aspergillosis**

| Author (yr) | No. of patients | HRCT thickness | Scan time (s) | Window width/level | Lobes or segments evaluated | Central bronchiectasis criteria | Patients with CB | Patients with PB | Lobes with CB/PB | Lobes with PB |
|---|---|---|---|---|---|---|---|---|---|---|
| Currie *et al*[13] (1987) | 9 | 3mm every 10 mm | 5.5 | Wide setting | NA | Subjective; based on proximity to hilum | 9 | 7 | 31 | 19 |
| Neeld *et al*[14] (1990) | 8 | 1.5 mm every 10 or 20 mm | | 2000/-550 | 46 lobes | Medial 2/3rd of the lung | 6 | 2 | 19 | 2 |
| Shah *et al*[15] (1992) | 2 | NA | 4.0 | 1000/-700 | 37 segments | Medial 2/3rd of the lung | 24 segments | None | | None |
| Angus *et al*[16] (1994) | 14 | 3 mm every 9 mm | 9.5 | NA | 102 lobes | Medial 2/3rd of the lung | 14 | 1 | 43 | 5 |
| Panchal *et al*[17] (1994) | 21 | 8 mm contiguous sections | 3-5 | NA | 336 segments | Medial 2/3rd of the lung | NA | NA | 212 segments | NA |
| Sandhu *et al*[18] (1994) | 15 | 8 mm contiguous scans (2-4 mm where required) | NA | 1000/-700 | 90 lobes | Medial 2/3rd of the lung | 44 | NA | 57 | 18 |
| Panchal *et al*[19] (1997) | 23 | 8 mm contiguous (4 mm if not clearly visualized) | 3-5 | NA | 134 lobes/ 406 segments | Medial 2/3rd of the lung | 23 | NA | 114 lobes 210 segments | 34 lobes 45 segments |
| Ward *et al*[20] (1999) | 44 | 1-3 mm every 10 mm at 5 selected levels | NA | NA | 264 | Medial 2/3rd of the lung | 28 | NA | 184 | NA |
| Mitchell *et al*[21] (2000) | 19 | 1-1.5 mm every 10-20 mm; 5 and 10 mm contiguous cuts also taken | 1-2 | NA | 114 | Medial 2/3rd of the lung | 18 | 15 | 101 | NA |
| Agarwal *et al*[22] (2006) | 126 | 1.25 mm every 10 mm | 3.0 | 1500/-600 | 431 lobes/ 1621 segments | Medial half of the lung midway between the hilum and chest wall | NA | NA | 255 lobes/ 664 segments | 99 lobes |

HRCT: High resolution computed tomography; CB: Central bronchiectasis.

the area of consolidation identified on the radiograph as mucus-filled bronchi in the majority of the patients, indicating that eosinophilic "pneumonia" is an uncommon finding of ABPA contrary to what has been previously believed. The likely reason is that previous studies describing chest radiographic findings in ABPA are of the pre-CT era and researchers could not corroborate their findings with HRCT of the chest.

Although CB is the most characteristic finding in ABPA, there is lack of uniformity in the definition of CB. Hansell *et al*[33] were the first to describe CB arbitrarily as dilated bronchi within a point midway radially from the hilum to the chest wall. Subsequently, authors have used different definitions including subjective criteria based on proximity to the hilum[13], and dilated bronchi within the medial two-thirds of the point radially from the hilum to the chest wall[14,16,17]. Although believed to be a characteristic finding in ABPA, the significance of CB as a specific diagnostic marker for ABPA is debatable as it has been shown that almost 40% of the involved lobes have bronchiectasis extending to the periphery[19,21,22]. In our study, the prevalence of CB was 43% and 33%, respectively, if CB was defined as the presence of bronchiectasis within the medial half or the medial two-thirds of the lung. Moreover, patients with asthma without ABPA can also develop CB[14,44]. Although bronchiectasis affecting three or more lobes, centrilobular nodules, and mucoid impaction on HRCT suggests ABPA rather than asthma[20], one study recognized all these findings in asthmatics with *Aspergillus* sensitization without ABPA[45]. Apart from CB, mucoid impaction was the commonest finding observed on HRCT in our study. The mucus plugs in ABPA are generally hypodense but can also be hyperdense; defined as a mucus plug visually denser than the paraspinal skeletal muscle[22]. The hyperattenuating character of mucus is ascribed to the presence of calcium salts and metals or desiccated mucus[46,47]. Recently, numerous reports have described the occurrence of HAM in ABPA[23,34,48-51], and currently the presence of HAM is considered a pathognomonic finding in ABPA[52].

To compare the HRCT chest findings of our study with those described in the literature, we have also performed a systematic review of PubMed and EmBase using free text search terms: allergic bronchopulmonary aspergillosis, ABPA. Our search yielded 3133 references of which 10 studies have reported HRCT chest findings of ABPA (Table 4)[13-22]. The studies have used different protocols for performance of CT, and most studies have used the definition of CB as dilated bronchi present within the medial two-thirds of the lung fields. The presence

of bronchiectasis extending to the periphery has also been variably described[13,14,16,18,19,22]. Most studies were retrospective and included patients who had already received glucocorticoids for treatment of ABPA[13,14,16,19-21]. Only one study described the presence of HAM in ABPA[22]. The presence of HAM in ABPA was first described by Goyal *et al*[53] although this radiological diagnosis was probably missed for long periods before[54] and even after description of this finding[18,55].

Although we have previously reported HRCT chest findings in ABPA[22], the limitation of the previous study was that we had not compared the chest radiograph findings with chest CT. Moreover, in this study we have used different definitions for defining CB to determine the change in prevalence of peripheral bronchiectasis in ABPA with different definitions. The prevalence of peripheral bronchiectasis has been variably reported as between 11% and 61%. Our study is different from the previous studies in that we included consecutive glucocorticoid-naïve patients diagnosed in the Chest Clinic. This is also reflected by the fact that almost 37% of the patients had a normal HRCT of the chest. It is the usual belief of clinicians and radiologists that all patients with ABPA should manifest with CB on chest HRCT. However, the earliest stage of ABPA is serologic ABPA (ABPA-S) in which the patients fulfill all diagnostic criteria of ABPA but do not manifest with any abnormalities on HRCT chest scan[56]. In fact, in asthma clinics where there is an active screening program for ABPA, almost 25% of ABPA patients will be diagnosed in the serological stage[35].

In conclusion, HRCT findings are useful in the diagnosis of ABPA; however, patients with ABPA can present with normal HRCT of the chest. CB cannot be considered a characteristic feature as peripheral bronchiectasis is commonly observed. Consolidation is an uncommon finding of ABPA while high-attenuation mucus, if present, is a characteristic finding of ABPA.

## COMMENTS

### Background

Allergic bronchopulmonary aspergillosis (ABPA) is a complex pulmonary disorder caused by immune reactions to antigens that are released by *Aspergillus fumigatus*, a ubiquitous fungus that colonizes the tracheobronchial tree of patients with asthma and cystic fibrosis. High resolution computed tomography (HRCT) of the chest is the radiological investigation of choice in patients with ABPA. Few studies have reported HRCT chest findings in patients with ABPA.

### Research frontiers

Most of the studies describing HRCT findings have focused their attention on detection of central bronchiectasis (CB) rather than describing the CT findings. In fact, only two studies have described the occurrence of centrilobular nodules in ABPA. Moreover, with time, change in disease epidemiology and better understanding of the disease, the radiological manifestations may be different from those originally described. For example, high-attenuation mucus has been a recently described radiological finding in ABPA. In this study, the author describe the chest radiographic and HRCT chest manifestations in glucocorticoid-naïve patients with ABPA diagnosed in the Chest Clinic of a tertiary care hospital in North India. Further, the authors also perform a systematic review of all the studies describing the HRCT chest manifestations of ABPA.

### Innovations and breakthroughs

Chest radiographs were normal in 50% of cases while in the remaining, most patients demonstrated permanent findings in the form of parallel line and ring shadows suggesting bronchiectasis. Consolidation was detected in 17 cases but in the majority, the corresponding HRCT chest scan showed mucus-filled bronchiectatic cavities. Chest HRCT was normal in 22 patients, while CB was demonstrated in the remaining 38 patients. Bronchiectasis extended to the periphery in 33%-43% depending on the criteria used for defining CB. The other findings observed on HRCT were mucoid impaction, centrilobular nodules and high-attenuation mucus in decreasing order of frequency.

### Applications

Patients with ABPA can present with normal HRCT of the chest. CB cannot be considered a characteristic feature of ABPA as peripheral bronchiectasis is commonly observed. Consolidation is an uncommon finding of ABPA

### Terminology

CB: CB can be defined using two different criteria; if bronchiectasis is confined to the medial half (point midway between hilum and chest wall) or the medial two-thirds of the lung; High-attenuation mucus: considered if the mucus is visually denser than the paraspinal skeletal muscle.

### Peer review

This is very interesting and well conducted study. It is worth of publication after some clarifications.

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