Atopic Pulmonary Disease: Findings on Thoracic Imaging

Rebecca G. Breslow
Harvard Medical School Year IV

Gillian Liebermam, MD

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Asthma

Atopic Pulmonary Disease

Allergic Bronchopulmonary Aspergillosis

Churg-Strauss Syndrome

Hypersensitivity Pneumonitis

Eosinophilic Pneumonia
Normal Lung Anatomy

Tracheobronchial Tree

Normal lung at level inferior pulmonary veins

Novelline and Squire, *Living Anatomy*, 1987

Asthma
Asthma: Pathophysiology and Work-up

- **Pathophysiology:**
  - airway inflammation, reversible airway obstruction, and hyperreactivity of airways to various stimuli

- **Work-up:**
  - Pulmonary function tests
    - documentation of physiologic airway obstruction that responds to a bronchodilator
  - Chest radiograph
  - Computed Tomography
Asthma

- Differential Diagnosis
  - vocal chord dysfunction
  - mechanical large airway obstruction
  - bronchiolitis
  - infiltrative lung disease
  - heart failure
  - hypersensitivity pneumonitis
  - allergic bronchopulmonary aspergillosis
Asthma: Chest Radiographs

- **Indications**
  - symptoms refractory to conventional treatment

- **Findings**
  - increased interstitial markings (bronchial wall thickening)
  - hyperinflation
  - complications related to severe asthma (status asthmaticus)
    - atelectasis
    - pneumothorax
    - pneumomediastinum
Asthma: Chest Radiographs

Hyperinflation
Asthma: Complications seen in Status Asthmaticus

Pneumomediastinum
www.usyd.edu.au/radiology/teaching

Atalectasis
UpToDate Online
Asthma: Computed Tomography

- **Indications**
  - detection of bronchiectasis in patients with suspicion of allergic bronchopulmonary aspergillosis
  - documenting presence and extent of emphysema in smokers with asthma
  - identifying conditions, such as hypersensitivity pneumonitis, which may be confused with asthma
  - quantification of changes in luminal diameter of asthmatic airways to aid clinical research studies

- **Findings**
  - bronchial wall thickening
  - bronchial dilatation
  - expiratory air trapping
Asthma: CT

Inspiratory Film

Expiratory Film

Air-Trapping

Courtesy of Dr. Phillip Boiselle, BIDMC
Allergic Bronchopulmonary Aspergillosis (ABPA)
ABPA: Pathophysiology and Work-Up

- **Pathophysiology**
  - *Aspergillus fumigatus* colonization of asthmatic airways prompts IgE- and IgG-mediated immune response (immediate hypersensitivity reaction)
  - Th2-mediated eosinophilic inflammation combines with proteolytic enzymes and mycotoxins released by fungi → airway damage

- **Work-Up**
  - Prick skin test to evaluate reactivity to Aspergillus antigens
  - Serum assay of total IgE and precipitins to Aspergillus
  - Chest radiographs
  - High resolution computed tomography
ABPA

- **Differential Diagnosis:**
  - obstructive pulmonary disease
  - infection
  - granulomatous disease
  - Churg-Strauss syndrome
  - bronchiolitis obliterans organizing pneumonia
  - chronic bronchitis
  - cystic fibrosis
  - bronchial adenoma
  - bronchogenic carcinoma
ABPA: Chest Radiographs

- **Indications:**
  - obtain during initial work-up as baseline study

- **Findings:**
  - central bronchiectasis with increased prominence in upper lobes
  - mucoid impaction ("toothpaste shadows" or "gloved-finger appearance" extending from hilum)
  - patchy parenchymal opacities (lobar, segmental or subsegmental) most commonly affecting the midzones
  - atelectasis due to proximal mucoid impaction
ABPA: High Resolution Computed Tomography

- **Indications:**
  - obtain if negative chest radiograph but prick skin test and serologic test positive (greater sensitivity for bronchiectasis)
  - serial studies useful to determine progression of disease

- **Findings:**
  - parenchymal infiltrates
  - bronchiectasis
  - mucoid impaction and atelectasis
  - bronchial wall thickening
ABPA: HRCT

Scout film

CT coronal reconstruction

Tubular opacities

Mucoid impaction and bronchial wall thickening

Courtesy of Dr. Phillip Boiselle, BIDMC
ABPA: HRCT

Axial images

"Gloved-finger shadows"
(intrabronchial exudates and bronchial wall thickening)

Courtesy of Dr. Phillip Boiselle, BIDMC
Chronic Eosinophilic Pneumonia (CEP)
CEP: Pathophysiology and Work-Up

Pathophysiology:
- an idiopathic disorder characterized by an abnormal accumulation of eosinophils in the lung
- accompanied or preceded by asthma in over 50% of cases

Work-up
- Measurement of peripheral eosinophil counts, IgE levels and ESR
- Bronchoalveolar lavage (>40% eosinophilia suggestive of CEP)
- Chest radiographs
- Computed tomography
Differential Diagnosis

- infection: tuberculosis, atypical pneumonia
- pulmonary fibrosis
- infiltrative lung disease
- obstructive pulmonary disease
- neoplasm
CEP: Chest Radiographs

- **Indications:**
  - distinctive pattern on chest radiograph helpful for diagnosis, though present in only 33% of cases
  - serial plain films used to monitor response to corticosteroid treatment

- **Findings**
  - bilateral peripheral or pleural-based infiltrates ("photographic negative" of pulmonary edema)

- **CT more sensitive for detection radiographic abnormalities,** but has not been shown to be superior to chest radiographs for assessment of disease activity
  - findings may persist on CT scan several weeks to months after complete resolution on plain films
CEP: Chest Radiographs

Infiltrate of eosinophils, histiocytes and multinucleated giant cells

UpToDate Online
Peripheral eosinophilic infiltrate at apex of R lung

Additional infiltrate at L apex not seen on CXR
Hypersensitivity
Pneumonitis (HP)
HP: Pathophysiology and Work-Up

- **Pathophysiology**
  - variable inflammatory reaction to inhalation of organic or inorganic particulates by sensitized individuals

- **Work-up**
  - Pulmonary function tests: restrictive or mixed pattern
  - Arterial blood gases: mild hypoxemia
  - Bronchoalveolar lavage: lymphocytosis
  - **High Resolution CT**
HP

- **Differential Diagnosis:**
  - Atypical pneumonia
  - Congestive heart failure
  - Other infiltrative lung disease: sarcoid
  - Obstructive pulmonary disease
HP: HRCT

- **Indications:**
  - gold standard for radiologic diagnosis of HP, since chest radiographs are normal in 87% of patients with this disease

- **Findings:**
  - diffuse micronodular or reticular opacities most prominent in middle to upper lung zones
  - ground glass attenuation
  - focal air trapping
  - fibrotic changes
HP: Ms. PS

Expiratory Film

Ground glass attenuation

Diffuse bronchial wall thickening

Air Trapping

Atalectasis

Expiratory Film

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Expi...
HP: Characteristics of the infiltrate

Giant Cells

Granulomas

Lymphoplasmic infiltrate in peribronchiolar distribution
Churg-Strauss Syndrome (CSS)
CSS: Pathophysiology and Work-Up

- **Pathophysiology:**
  - systemic vasculitis, extravascular granulomas and prominent peripheral blood eosinophilia in patients with a history of asthma and/or allergy
  - multisystem, but predominant sites of involvement = lung, skin, nervous system

- **Work-Up:**
  - peripheral blood eosinophilia in range of 5000-9000/uL
  - P-ANCA positivity
  - elevated ESR
  - elevated IgE
  - surgical biopsy of lung or other involved organ demonstrating eosinophilic infiltrate, necrosis, giant cell vasculitis of small arteries and veins, necrotizing granulomas
  - CXR
  - HRCT
Differential Diagnosis:

- asthma
- chronic eosinophilic pneumonia
- Wegener’s granulomatosis
- lymphomatoid granulomatosis
- necrotizing sarcoid granulomatosis
- bronchocentric granulomatosis
- polyarteritis nodosum
CSS: Chest Radiographs

- **Indications:**
  - findings are diverse, so more useful for monitoring of disease progression than for diagnosis

- **Findings:**
  - most common is bilateral, patchy, multifocal opacities without lobar or segmental distribution
  - interstitial or miliary opacities
  - widespread shadowing from pulmonary hemorrhage
  - bilateral, nodular disease
  - hilar adenopathy
  - pleural effusions
CSS: HRCT

- **Indications:**
  - has been found to correlate with histological appearance of pulmonary parenchyma on open lung biopsy, so useful for diagnosis and monitoring

- **Findings:**
  - diffuse, patchy opacities
  - “halo sign”: centrilobular nodules within ground-glass opacity
  - “vasculitis sign”: peripheral pulmonary arteries are enlarged and exhibit stellate and irregular configuration
  - bronchial wall thickening and air-trapping
CSS: Mr. JD

Diffuse, bilateral parenchymal consolidation

Courtesy of Dr. Phillip Boiselle, BIDMC
CSS: Imaging

Patterns:

Multifocal consolidation

lobular-sparing

lobular
CSS: Imaging


Non-segmental consolidation

“Halo sign”

Consolidation

Bronchial wall thickening
CSS: Imaging

Necrotizing granulomatous vasculitis

Air-trapping

Ground-glass opacity with centrilobular nodules

wall thickening

Conclusions

- Thoracic imaging can aid in diagnosis of atopic pulmonary disease.
- It is also useful for monitoring of disease progression.
- Chest radiographs exhibit many characteristic findings, but high-resolution computed tomography is more sensitive for detection of pulmonary pathology in these diseases.
- Thoracic imaging can correlate with histopathology, so may offer a less invasive alternative to surgical lung biopsy.
References

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