BRONCHIECTASIS
Campbelltown / ALF
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CF61 XX.
Bronchiectasis

“dilated airways”
BRONCHIECTASIS - history

- “bronckos” + “ektasis”

- Laennec 1819 described clinical entity
  - PM specimens and clinical observations
  - long history, progressive nature
  - cough, prolific sputum production
- expanding on that

- permanent dilatation of bronchi
- this was the obvious feature on early PM specimens, x-rays (of “worst” cases)
- … but it’s a patchy process
- areas of narrowing, areas of dilatation
- altered anatomy interferes with drainage
Normal lung function (1)

- Get air IN
- Get $O_2$ out of the air and INTO the blood
- Get $CO_2$ out of the blood
- Blow off the waste $CO_2$ - ie …get air OUT
- Repeat, according to metabolic demands!

- AT REST: 600 mls every 5 seconds – 5 L/min
- V HARD WORK: 5000 mls every 1.5 seconds – 200 L/min (Vmax)
Normal lung function (2)

- Lung weighs about 1 kg
- 60% is lung tissue, 40% blood
- Alveolar gas to capillary blood distance is 1.5 um (red cell size 6 um)
- Pulmonary blood flows in a stream one red blood cell thick
- Lung SA “a tennis court” ~ 70 m²
A  Normal lung

B  Bronchiectasis
CLINICAL FEATURES - HISTORY

- chronic cough
- sputum production, may be bloody
- repeated bouts/treatment of “bronchitis” (respiratory infection)
- gradual deterioration if no interventions
  - all symptoms, severity, progress vary
THE VICIOUS CYCLE

CAUSATIVE INSULT → Damaged airways, poor drainage

Damaged airways, poor drainage → Infection and inflammation

Infection and inflammation → More damage

More damage → Worsening of natural drainage

Worsening of natural drainage → CAUSATIVE INSULT
Cough; dry or wet; noise at mouth
Wheezing + crackles (snap crackle pop)
Blue, cyanosis (low oxygen levels)
Finger clubbing if there has been a lot of purulent infection over a long time
Arthritis (rheumatoid arthritis)
Dry eyes, dry mouth
Skin changes (scleroderma)
Repeated skin sepsis (low IG levels)
Sinus disease, etc etc (CF, PCD)
Infertility (CF, PCD)
more photographs ...

- mugs full of sputum? bloody sputum?

- PM lungs with severe bronchiectasis
  - damage, holes, pus
Conglomerating cysts of varying size and wall thickness

"Honeycomb" sign
dilated airways
thickened airway walls

irregular peripheral opacities (mucus)
BRONCHIECTASIS - history

- pre x-ray era; clinical, “take the waters”
- first successful resection 1901
- first bronchogram 1922 (trans-cricoid)
“Curse Sir Walter Raleigh, he was such a stupid git!”

(John Lennon, 1968)

Sir Walter Raleigh 1552 – 1618
<table>
<thead>
<tr>
<th></th>
<th>Bronchiectasis</th>
<th>COPD</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Etiology</strong></td>
<td>Infection or genetic or immune defect</td>
<td>Cigarette smoking</td>
</tr>
<tr>
<td><strong>Role of infection</strong></td>
<td>Primary</td>
<td>Secondary</td>
</tr>
<tr>
<td><strong>Predominant organism in sputum</strong></td>
<td>Haemophilus influenzae, Pseudomonas aeruginosa</td>
<td>Streptococcus pneumoniae, H. influenzae</td>
</tr>
<tr>
<td><strong>Airflow obstruction and hyperresponsiveness</strong></td>
<td>Present</td>
<td>Present</td>
</tr>
<tr>
<td><strong>Findings on chest imaging</strong></td>
<td>Airway dilation and thickening, mucous plugs</td>
<td>Hyperluency, hyperinflation, airway dilation</td>
</tr>
<tr>
<td><strong>Quality of sputum</strong></td>
<td>Purulent, three-layered</td>
<td>Mucoid, clear</td>
</tr>
</tbody>
</table>

† Reproduced with permission from: Barker, AF. Bronchiectasis. N Engl J Med 2002; 346:1383. Copyright © 2002 Massachusetts Medical Society. All rights reserved.
BRONCHIECTASIS – summary/dx

... shares features with COPD, but more cough
- inflamed and easily collapsible airways
- obstruction to airflow on spirometry
- frequent office visits and hospitalizations

DIAGNOSIS usually clinical + radiological (CT)
- chronic daily cough with viscid sputum
- bronchial wall thickening & luminal dilatation
BRONCHIECTASIS – epidemiology (population study)

- prevalence unclear, under-reported?
- ‘40 to 50 per 100 000’ (US data)
- = 250 in Tasmania … seems low

- “low and probably decreasing”
  - better treatment of pneumonia, TB
“low and probably decreasing”
- cystic fibrosis
- post-pneumonia etc
- hereditary eg … low immunoglobulins

*improved CF survival … adult physicians are seeing more bronchiectasis there*
BRONCHIECTASIS
- CF as a model

cystic fibrosis, ‘mucoviscidosis’

- ‘cyst’ formation (tissue destruction)
- ‘fibrosis’ = scarring, gradual stiffening of remaining lung
- mucus + ‘viscous’ (sticky, inflamed, hard to clear)
HRCT with ring shadows (dilated airways)
- many filled with secretions
BRONCHIECTASIS
- CT impact on diagnosis

Previously unsuspected cases diagnosed
Identical on x-ray to clinically more severe cases
Many cases previously ascribed to ‘asthma’, COPD, recurrent bronchitis
“iceberg” phenomenon
Where’s the cut-off?
Clinical features of bronchiectasis (1)

cough with months or even years of daily sputum production (mucopurulent and/or tenacious) +/- haemoptysis

“Dry bronchiectasis” … episodic haemoptysis but no sputum (less common presentation)

Other less specific complaints:
- dyspnoea, wheeze, and pleurisy; may mimic asthma
- frequent "bronchitis" requiring repeated antibiotic therapy
- repeated respiratory tract infections over several years
- a “sentinel” episode of severe bacterial pneumonia (pertussis, measles, TB, or Mycoplasma may cause bronchiectasis)
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Clinical features of bronchiectasis (2)

123 patients: 38 male and 85 female, mean age 57 *
- patients all proven on CT, bronchogram, or surgery

Symptoms - cough (90%), daily sputum (76%), dyspnoea (72%), haemoptysis (56%), recurrent pleurisy (46%), never smoked (55%)

Findings - crackles (70%), wheeze (34%), digital clubbing (3%), abnormal plain chest film (91%)

Causation - 70% nominated a specific event (usually a pneumonic episode)

* Nicotra, Chest 1995 108:955
PATHOPHYSIOLOGY AND AETIOLOGY of BRONCHIECTASIS

acquired disorder of major bronchi + bronchioles

characterized by permanent abnormal dilatation of airways and destruction of bronchial walls

affected areas show a variety of changes:
- transmural inflammation
- mucosal oedema
- cratering and ulceration with bronchial neo-vascularization
- distortion due to scarring
- obstruction from repeated infection
- post-obstructive pneumonitis; distal lung parenchymal damage
# Predisposing Factors for Bronchiectasis

- **Infectious insult**
- **Impaired drainage**
- **Airway obstruction**
- **Defective host defense**

## Specific Etiology

### Bronchopulmonary Infections
- **Childhood infections**
  - Pertussis; measles
- **Bacterial infections**
  - Infections due to *S. aureus*, *Klebsiella*, *M. tuberculosis*, *H. influenzae*
- **Viral infections**
  - Infections due to adenovirus (particularly types 7 and 21), influenza, herpes simplex; viral bronchiolitis; HIV
- **Other infections**
  - Fungal (histoplasmosis); nontuberculous mycobacteria; ? mycoplasma

### Bronchial Obstruction
- **Foreign-body aspiration**
  - Peanut; chicken bone; tooth; grass inflorescence, etc.
- **Neoplasms**
  - Laryngeal papillomatosis; airway adenomas; bronchogenic carcinoma
- **Hilar adenopathy**
  - Tuberculosis; histoplasmosis; sarcoidosis
- **COPD**
  - Chronic bronchitis
- **Acquired tracheobronchial disease**
  - Relapsing polychondritis; tracheobronchial amyloidosis
- **Mucoid impaction**
  - Allergic bronchopulmonary aspergillosis; bronchocentric granulomatosis; postoperative mucoid impaction

### Congenital Anatomic Defects
- **Tracheobronchial**
  - Bronchomalacia; bronchial cysts; cartilage deficiency (Williams-Campbell syndrome); tracheobronchomegaly (Mounier-Kuhn syndrome); ectopic bronchus; endobronchial teratoma; tracheoesophageal fistula
- **Vascular**
  - Pulmonary (intralobar) sequestration; pulmonary artery aneurysm
- **Lymphatic**
  - Yellow-nail syndrome

### Immunodeficiency States
- **IgG deficiency**
  - Congenital (Bruton’s type) agammaglobulinemia; selective deficiency of subclasses (IgG2, IgG4); acquired immune globulin deficiency; common variable hypogamma-globulinemia; Nezelof’s syndrome; “bare lymphocyte” syndrome
- **IgA deficiency**
  - Selective IgA deficiency ± ataxia-teleangiectasia syndrome
- **Leukocyte dysfunction**
  - Chronic granulomatous disease

### Hereditary Abnormalities
- **Ciliary defects of airway mucosa**
  - Kartagener’s syndrome; immotile cilia syndrome; ciliary dyskinesia
- **Alpha-1-antitrypsin deficiency**
  - Absent or abnormal antitrypsin synthesis and function
- **Cystic fibrosis (muoviscidosis)**
  - Typical early childhood syndrome; later presentation with solely pulmonary symptoms

### Miscellaneous Disorders
- **Young’s syndrome**
  - Obstructive azoospermia with sinopulmonary infections
- **Recurrent aspiration pneumonia**
  - Alcoholism; neurologic disorders; lipid pneumonia
- **Inhalation of irritants**
  - Ammonia; nitrogen dioxide, or other irritant gases; smoke; talc; silicates; detergents
- **Connective-tissue disease**
  - Associated with rheumatoid arthritis and Sjögren’s syndrome
- **Following combined heart-lung transplantation**
  - Associated with obliterator bronchiolitis

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PATHOPHYSIOLOGY AND AETIOLOGY of BRONCHIECTASIS (3)

- 1) Infectious insult
- 2) Impairment of:
  - drainage
  - airway patency
  - host defense

- ensuing tissue injury mediated in part by host response:
  - airway immune effector cells
  - neutrophil proteases
  - reactive oxygen intermediates including H2O2
  - inflammatory cytokines eg: interleukin-8
‘GERMS’

Microbiology in Bronchiectasis

- Li, 2005
- Nicotra, 1995
- Pasteur, 2000

<table>
<thead>
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<th>Li, 2005</th>
<th>Nicotra, 1995</th>
<th>Pasteur, 2000</th>
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<tbody>
<tr>
<td>H. influenzae</td>
<td>40</td>
<td>30</td>
<td>35</td>
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<tr>
<td>S. pneumoniae</td>
<td>30</td>
<td>18</td>
<td>11</td>
</tr>
<tr>
<td>P. aeruginosa</td>
<td>31</td>
<td>11</td>
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</tr>
<tr>
<td>S. aureus</td>
<td>11</td>
<td>7</td>
<td>4</td>
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<tr>
<td>M. catarrhalis</td>
<td>20</td>
<td>2</td>
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<tr>
<td>Aspergillus spp.</td>
<td>20</td>
<td>1</td>
<td>5</td>
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<tr>
<td>Mycobacteria</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>2 or more</td>
<td>0</td>
<td>6</td>
<td>0</td>
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THE VICIOUS CYCLE

CAUSATIVE INSULT

Damaged airways, poor drainage

Infection and inflammation

Worsening of natural drainage

More damage

More damage

THE VICIOUS CYCLE
Bronchiectasis due to airway obstruction – especially FB

1) foreign body aspiration (especially in children aged 1-3, R > L, LL > UL)
2) intra-luminal obstruction eg: by a carcinoid tumor
3) extra-luminal compression from encroaching lymph nodes

- all important to identify because surgical cure may be possible
  - witnessed or recognized aspiration is uncommon
  - ? an episode of choking + coughing, unexplained wheezing, or haemoptysis
  - Adult aspirators usually do so during an altered state of consciousness
    - stroke, seizure, intoxication, or emergent general anesthesia
    - the foreign body is often unchewed food, or part of a tooth or crown

- post-obstructive pneumonia can follow the aspiration event
- poor resolution, lung abscess, prolonged pneumonitis, focal bronchiectasis

- 86% of airway foreign bodies can be removed using flexible bronchoscope *

other tests

• bronchial biopsy (ciliary ultrastructure)
• bronchoscopy – obstructing lesion?
• aspergillus precipitins / antibodies
• serum IgE
• Ig subclasses (defence proteins)
• alpha 1 – antitrypsin (concentracion / phenotype)
• RF
• sperm motility
Diagnosis – Chest CT

Cylindrical bronchiectasis
Varicose bronchiectasis
Traction bronchiectasis (fibrosis)
**Bronchiectasis** HRCT shows numerous ring shadows representing dilated airways in the right lung, many of which are partially filled with secretions (arrow). Courtesy of Alan Barker, MD.
Note characteristic location in the upper lobes and superior segments of lower lobes.
Cystis / saccular bronchiectasis
Bronchiectasis with marked airway dilatation
HRCT shows clustering of markedly dilated airways in both upper lobes (arrows). Courtesy of Alan Barker, MD.
Characteristic central bronchiectasis 2/2 ABPA
Bronchiectasis: Summary

- Abnormal irreversibly dilated and often thick-walled bronchi
- Pathogenesis related to one or more defects of mucociliary clearance, cellular and immunity defense mechanism or presence of associated conditions
- “The vicious cycle” and *P. aeruginosa* contributes progression and severity of disease
- Imaging greatly helps in diagnosis: Tram line, honeycombing, cystic, signet ring sign
- Additional test may be required in specific clinical settings
- Microbiology of the diseased airway may aid proper antimicrobial therapy
Normal lung function

- Normal VC
- Normal flow
- Flow governed by volume and elastic lung recoil
FEV₁ DECLINE

Never smoked or not susceptible to smoke

Susceptible smoker

Disability

Death

FEV₁ (percentage of value at age 25)

Age (years)
Bronchiectasis: Summary

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Pathogenesis of Bronchiectasis: The Vicious Cycle

**Infection**
with acute inflammation and recruitment of inflammatory cells

**Release**
of inflammatory cytokines, peroxidases, proteinases, elastase, etc.

**Colonization**
and biofilm formation, intermittent dispersals

**Destruction**
of mucociliary and cartilagenous supporting structures

**Impairment**
mucociliary clearance, sputum retention

**Loss**
of ventilatory function
Management

... interrupt that vicious cycle
THE VICIOUS CYCLE

CAUSATIVE INSULT

Damaged airways, poor drainage

Infection and inflammation

Worsening of natural drainage

More damage

More damage
THE VICIOUS CYCLE

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IMPROVE DRAINAGE
THE VICIOUS CYCLE

CAUSATIVE INSULT

Damaged airways, poor drainage

Worsening of natural drainage

Infection and inflammation

More damage

PREVENT INFECTION, REDUCE THE INFLAMMATION

IMPROVE DRAINAGE
THE VICIOUS CYCLE

CORRECT IF POSSIBLE – REPLACE IgG etc

CAUSATIVE INSULT

Damaged airways, poor drainage

IMPROVE DRAINAGE

Worsening of natural drainage

Infection and inflammation

PREVENT INFECTION, REDUCE THE INFLAMMATION

More damage