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Bronchiectasis in the Elderly—a Disease That Has Not Gone Away

Michelle Brennan[1] · M. J. McDonnell[1] · C. Ward[2] · A. Alamer[2] · N. Duignan[1] · R. M. Rutherford[1]

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Abstract

Purpose of Review In the early twentieth century, bronchiectasis (BE) was not a disease seen in the elderly population as life expectancy was usually < 40 years. A century on, however, and this is now a disease much more prevalent in the elderly and as patients live longer, this trend will almost certainly continue. Why is this so? (1) BE is irreversible and often worsens with advancing years and (2) aetiologies associated with new-onset BE in the elderly are strongly related to the ageing process itself—namely gastro-oesophageal reflux disease (GORD), immunosenescence, cancer and inflammatory diseases, oral sepsis, aspiration of food and liquid into the respiratory tract and development of pulmonary fibrosis. BE can also complicate chronic airway diseases such as COPD, which becomes more prevalent with age, and is associated with more rapid disease progression and a higher mortality. In both the BSI and FACED BE mortality prediction scores, age is an independent risk factor for death.

Recent Findings At present, GORD and aspiration are considered to be the primary cause of few cases of BE. There is however a lot of data supporting the role of GORD and the severity of BE and its prognosis. Similarly, the data implicating aspiration in elderly patients as a major risk factor for the development of community-acquired pneumonia is overwhelming yet it is rarely looked for and the subsequent bronchiectasis is usually labelled as post-infective rather than due to aspiration.

Summary In older patients with recurrent chest infections and/or chronic cough and sputum, it is, therefore, critical to think of BE and investigate appropriately including testing for GORD and aspiration. Treatment involves attenuation of risk wherever possible and the twin pillars of sputum clearance and judicious use of antibiotics.

Keywords Bronchiectasis · Older person · Gastro-oesophageal reflux disease · Aspiration · Lady Windermere syndrome

Introduction

Bronchiectasis (BE) is a chronic inflammatory lung disease first described in nineteenth century literature and later defined pathologically by Lynne Reid in the 1950s as permanent dilatation of the bronchial tree [1]. In the pre-antibiotic/vaccination era, survival was typically < 40 years of age [2] but with modern healthcare, this has risen to over the age of 70 but still carries a 20% 5-year mortality from diagnosis [3, 4]. A watershed in the history of this disease was the publication of British thoracic and European Respiratory Society guidelines for diagnosis and management in 2010 [5] and 2017 [6•] respectively. The prevalence of BE is increasing [7], and undoubtedly, many cases remain undiagnosed. Interestingly, because of the natural history of the disease, the average latent period of recurrent infections before diagnosis may be up to 17 years [8]. This is because of 3 main reasons: (a) infections usually commence relatively mild and more separated in time. However, each infection results in more damage to the airway wall and mucociliary apparatus, which in turn leads to more infection and often bacterial colonisation. A vicious cycle of progresive airway damage then ensues. (b) unlike asthma and COPD where spirometry can be diagnostic, BE requires specialised imaging, i.e. high-resolution CT, which has limited availability, secures a diagnosis and (c) a low index of suspicion still exists for the disease.

BE is now an age-associated disease with 50% of new cases being diagnosed over the age of 65 and almost 20% over 75 years in one study [9•] with another study reporting an even higher mean age of diagnosis [10]. A number of aetiologies of BE are not specific to the elderly but are acquired earlier in life and progress with age. Some aetiologies, however, as we will

✉ Michelle Brennan
mich.brennan90@gmail.com

[1] Department of Respiratory Medicine, University Hospital Galway, Newcastle Road, Galway H91 YR71, Ireland

[2] Translational and Clinical Research Institute, Newcastle University, Newcastle, UK

discuss below, are elderly specific. Prediction tools such as the BE Severity Index (BSI) [11] and FACED [12] have been devised to predict the future mortality rate; see Table 1. Age is an independent risk factor in both tools with increasing age associated with a worse prognosis. A study analysing six European databases showed that patients greater than 75 years had more comorbidities, worse quality of life and higher mortality.

The aetiology known to cause BE is outlined in Table 2 and Fig. 1a [4]. The simplest ways to divide aetiologies of BE are idiopathic, acute airway insult, reduced innate immunity, chronic airway inflammation and traction. We look at each of these in turn with a view to the older person.

Acute Airway Insult

This is usually the result of acute infection. Developing lungs appear to be much more easily damaged than mature lungs, thus the classical BE post whooping cough and measles in childhood. The risk of community-acquired pneumonia, however, increases significantly with age [13•], and this may be due to reduced immunity, underlying airway and lung pathology, certain comorbidities and heightened aspiration risk.

The pattern of bronchiectasis can be helpful in identifying an underlying aetiology. Localised bronchiectasis can be secondary to a variety of causes, including obstructing tumour, endobronchial foreign body or infection such as tuberculosis.

Slow-growing endobronchial or peribronchial tumours,, e.g. carcinoid, can cause focal bronchiectasis in a lobe, segment or even isolated to a single bronchus. This chronic obstruction can lead to airway damage and post obstructive infection.

Localised bronchiectasis should also raise suspicion for an aspirated foreign body. Other clinical and radiological clues may be an unresolving pneumonia, localised area of air trapping or hyper-lucency or empyema in an adult patient. Foreign body aspiration in adults is more common in the setting of advanced age, underlying neurological disorder, poor dentition, alcohol consumption and sedative use or can occur in the absence of any predisposing risk factor. Flexible bronchoscopy is the treatment of choice in majority of patients. Rigid bronchoscopy or even thoracotomy may be required in certain cases, usually dependent on the consistency and size of the aspirated material. A delay in presentation or recognition may lead to serious complications, emphasising the importance of early diagnosis in this potentially dangerous but completely reversible condition.

Pneumonia later in life can also cause BE and older patients would thus be at higher risk of post-infective BE. Other causes of a single acute airway insult are rare, e.g. a single large volume aspiration. If the patient survives such an episode, it

Table 1 Commonly used scoring systems in bronchiectasis and respiratory disease

Score	Severity marker	Severity score
Bronchiectasis Severity Index (BSI)	- BMI - %FEV1 predicted - Previous hospital admission - Hospitalisation with a severe exacerbation in the past 2 years? - Number of exacerbations in previous year - MMRC Breathlessness Score - Pseudomonas colonisation - Colonisation with other organisms - Radiological severity 1 point each	0–4 points mild bronchiectasis 5–8 points moderate bronchiectasis 9+ points severe bronchiectasis
FACED score	F—FEV1(≥ 50% = 0 points, < 50% = 2 points) A—Age (< 70 years = 0 points, ≥ 70 years = 2 points) C—Chronic colonisation (no *Pseudomonas* = 0 points, presence of *Pseudomonas* = 1 point) E—Extension (1–2 lobes affected = 0 points, > 2 lobes affected = 1 point) D—Dyspnoea—modified Medical Research Council scale—mMRC (0–2 = 0 points, 3–4 = 1 point)	0–2 points mild bronchiectasis 3–4 points moderate bronchiectasis 5–7 points severe bronchiectasis
CURB-65 score	Confusion Blood urea nitrogen > 7 mmol/L Respiratory rate ≥ 30 breaths/min Systolic blood pressure < 90 mmHg or Diastolic blood pressure < 60 mmHg Age ≥ 65 1 point each	0–1 points: low risk Suitable for outpatient care 2 points: moderate risk Inpatient vs observation admission 3 points or more: high risk Inpatient admission with consideration for ICU admission

Table 2 Aetiology of bronchiectasis

Cause	Examples
Idiopathic (40%)	
Acute airway insult	Post-infectious Inhalational injury
Reduced innate immunity	Immunodeficiency Alpha-1-antitrypsin deficiency Cystic fibrosis Primary ciliary dyskinesia Young syndrome Cartilage deficiency Obstructive lesions
Chronic airway inflammation	COPD Connective tissue disease, e.g. Rheumatoid Arthritis (RA) bronchial asthma Allergic bronchopulmonary aspergillosis Gastro-oesophageal reflux disease (GORD) Aspiration Mycobacterium, e.g. tuberculosis, *Mycobacterium avium* intracellulare Inflammatory bowel disease
Traction	Pulmonary fibrosis

can cause severe airway damage. Elderly patients may be at higher risk of this because of increased stroke and syncope frequency including seizure.

Reduced Innate Immunity

Immunosenescence, or gradual deterioration in the immune system with ageing, begins to occur after the age of 65 years. The host's capacity to respond to infections and the development of long-term immune memory following vaccinations deteriorate resulting in an increased risk of infection. Bronchoalveolar lavage fluid in older patients have shown an increased proportion of neutrophils, increase in CD4+/CD8+ ratio of lymphocytes and increase in alveolar macrophages and superoxide anion release [14]. As stated previously, elderly patients are at a heightened risk of community-acquired pneumonia [13•] and age is a separate risk factor in the CURB-65 score for severity [15]. Pneumonic change on chest radiograph takes longer to clear in the elderly [16] so the inflammatory response may be prolonged, and there may be increased risk of airway damage as a result.

In tandem with immunosenescence, elderly patients are treated more aggressively than ever for a wide range of malignant and inflammatory conditions. Cytotoxic drugs, targeted therapies, TNF inhibitors, corticosteroids and rituximab can all lead to further immunosuppression from neutropenia, diminished T cell and B cell responses and reduced immunity to atypical mycobacteria, yeast and fungal infections which can cause BE or cause progression of BE if already present.

Rheumatoid arthritis (RA) is a particular case in point which is diagnosed over a wide age range (30–60 years) and many elderly patients are now treated for RA with potent immunosuppressive agents which have improved all disease parameters including survival. However, about 17% of patients with rheumatoid arthritis have radiological evidence of BE [17] and about 5–7% have clinical BE [9•, 18]. In fact, RA-associated BE straddles both chronic airway inflammation and reduced immunity. RA often precedes the development of BE in most cases and BE does not influence or reflect RA severity. Concurrent RA and BE is postulated to be due to similar genetic predisposition, whereby the lung may be an early manifestation of autoimmune-related injury. Several genetic mutations, immunoglobulins and human leucocyte antigens have been the subject of several small studies without any consistent findings to date. BE also occurs in the setting of treatment regimes for RA. The use of disease modifying anti rheumatoid drugs (DMARDS) such as methotrexate and biological agents, in addition to frequent or prolonged courses of corticosteroids, suppresses the immune system and can predispose to the development of recurrent and severe infection which subsequently leads to BE. The present authors found RA patients to have a poor prognosis, with a mortality double that of idiopathic BE because the combination of airway suppuration in the setting of immunosuppression is often very deleterious resulting in rapid progression of BE [19]. It is very important to check serum immunoglobulin levels in RA patients on rituximab. The authors recently described dramatic deterioration of BE in a patient with RA-associated BE

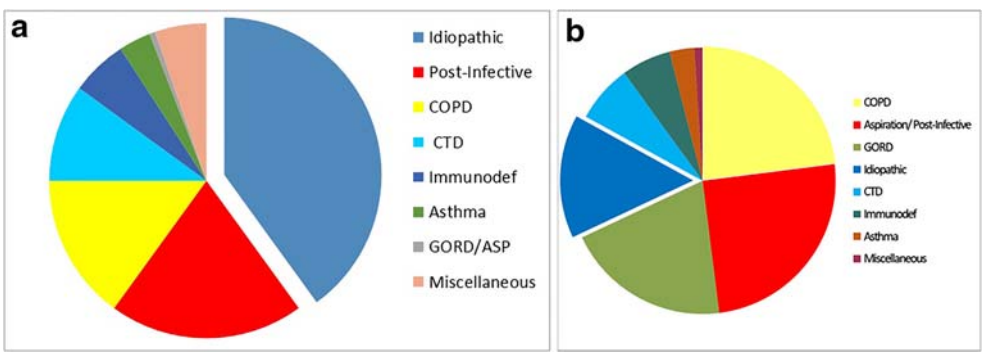

Fig. 1 **a** Current aetiologies of bronchiectasis [4]. **b** Potential future aetiologies of bronchiectasis in the elderly

resulting in chronic respiratory failure who was treated with rituximab and developed unrecognised hypogammaglobulinaemia [20].

Patients with chronic lymphocytic leukaemia (CLL) are also worthy of a specific mention. These patients are often significantly immunosuppressed. The average age of onset of is 65 to 70 years old, and about one quarter of these patients have hypogammaglobulinaemia at diagnosis [21]. Many develop recurrent airway sepsis and can develop BE. Rituximab is also often used in combination with other therapies to treat CLL [22], and again, immunoglobulin levels have to be monitored carefully.

Chronic Airway Inflammation

This is probably the most important area in the genesis of BE in elderly patients. Rheumatoid arthritis-associated BE is already described above.

COPD/BE Overlap

COPD has an estimated prevalence of just over 10% worldwide in patients over the age of 40, and it is about double that in the very elderly [23]. One problem with COPD prevalence studies in the elderly is that the FEV1/FVC ratio tends to fall significantly with age, and up to 80% of 80-year-olds can be misdiagnosed as COPD when in fact they have no significant airways disorder [24].

COPD is almost certainly the single biggest known cause of BE. It is estimated that about 50% of COPD patients attending hospital clinics have coexistent BE [25, 26]. These patients tend to have more exacerbations; more sputum production; more resistant organisms, including *Pseudomonas aeruginosa*, and more severe airflow obstruction [27]. High-frequency exacerbators should have a high-resolution CT thorax to look for BE and enhanced sputum surveillance. More aggressive treatment of acute exacerbations for example high-dose antibiotics for 2 weeks and use of the intravenous route where necessary, chronic treatment with mucolytics, sputum clearance physiotherapy, prophylactic oral and/or inhaled antibiotics all may play a significant role in reducing the frequency of exacerbation in COPD/BE overlap syndrome.

The most evidence for the benefits of oral prophylactic antibiotics in COPD is a study by Albert et al. in 2011 that demonstrated a 30% reduction in exacerbation frequency in patients taking azithromycin 250 mg once daily versus placebo for 1 year [28]. It is not known what proportion of these COPD patients had BE as well. Azithromycin is recommended in the current GOLD guidelines [29] for Class D patients still exacerbating despite inhaled corticosteroids and inhaled long-acting beta agonist and anti-muscarinic therapy. With worsening airflow obstruction, a number of COPD patients, including those with BE, get marked dynamic expiratory airway collapse. This can be seen on expiratory HRCT images and at bronchoscopy. Sputum tends to get trapped in the lungs on coughing due to proximal airway collapse, and this can respond very well to positive-end-expiratory-pressure-based physiotherapy techniques such as using a PEP mask [30] or a bi-level non-invasive ventilator.

Gastro-Oesophageal Reflux Disease

In the study of 1258 patients by Bellelli et al., GORD and dysphagia were implicated in 1% of BE and there was no significant difference when patients were stratified into different age groups [9•]. In the authors' clinical practice, however, GORD is frequently diagnosed as a cause of BE that has been previously mislabelled as idiopathic [31•]. Gastro-oesophageal reflux is usually prevented by the lower oesophageal sphincter, the crural diaphragm and the anatomical flap valve. If GORD is to cause BE, then gastric reflux would have to reach the larynx and enter the bronchial tree. This is termed extra-oesophageal reflux. A hypotensive lower oesophageal sphincter is a common cause of reflux, but the strongest risk factor for reflux is the presence of a hiatus hernia (HH) were a significant portion of the stomach migrates into the lower thorax. The prevalence of HH increases with age as connective tissue weakens and increased central obesity results in an increased abdominal-thorax pressure gradient.

GORD and BE may also interact with each other in other negative ways:

1. Repeated bouts of coughing can lead to acute spikes in intra-abdominal pressure which may cause acute reflux and over time may force the stomach through the diaphragm.
2. In BE, hyperinflation with lower flat diaphragms may cause a hypotensive lower oesophageal sphincter and predispose to reflux
3. Severe airflow obstruction requires greater negative intrapleural pressure to be generated to inspire, and this may also have a siphoning effect on secretions from the stomach into the lower oesophagus.
4. Bronchodilators such as beta-2 agonists, anti-muscarinic agents and theophyllines can also relax smooth muscle and lower the tone in the oesophagus and create a pressure gradient from the stomach to the oesophagus.

The diagnosis of GORD can be difficult. Identifying a hiatus hernia (HH) on CT scan of the thorax, barium swallow, 24 h oesophageal pH manometry or OGD is often used as a surrogate for GORD. The authors have shown previously that the presence of HHs are associated with more severe BE. Of 81 patients with a mean age 63 years, 29 (36%) had a HH and these patients had worse radiological disease and lung

function impairment [32]. Forty-two per cent to 73% of BE cases caused by GORD may be asymptomatic as regards reflux symptoms. Symptoms and questionnaires have produced variable results in diagnosing GORD. Twenty-four hours oesophageal pH impedance/manometry, which is seen as the gold standard for diagnosing reflux, has shown a variable prevalence with rates of 11–75% reported in some studies [33, 34]. There is strong evidence that GORD-associated BE tends to be more severe with more exacerbations, worse physiological impairment, higher rates of bacterial colonization, lower quality of life and a higher mortality [35, 36].

The effect of treating GORD in BE is not very clear. Retrospective studies using proton pump inhibitors have not shown benefit as non-acid, gaseous and biliary reflux may also be pathogenic, but a small case series involving Stretta radiofrequency (a minimally invasive endoscopic procedure delivering electromagnetic waves though electrodes via a catheter to the lower oesophageal sphincter and gastric cardia) and/or laparoscopic fundoplication was shown to be very beneficial [37]. Standard anti-reflux measures such as avoiding provoking foodstuffs, weight reduction and elevating the head of the bed are also strongly advised. However, there is no evidence regarding the use of prophylactic antibiotics. Our strategy is to use co-amoxiclav 625 mg twice daily because of its effect on gram-positive, gram-negative and anaerobic organisms and anecdotally, we have had some very good outcomes with this approach.

Bronchial Asthma

About 10% of asthmatics have severe asthma and roughly half of these patients develop BE. These patients tend to be middle-aged and a few years older than asthmatic patients without BE and have more exacerbations and hospital admissions [38]. While 15% of BE patients have significant reversibility with bronchodilators, this is not the same group as patients who have a primary diagnosis of asthma which becomes complicated by BE.

The aetiology of BE in asthma is probably due to a combination of factors including repeated mucus plugging, infections, gastro-oesophageal reflux, intense eosinophilic inflammation and mechanical issues with sputum clearance such as dynamic airways collapse and sputum viscosity. Interestingly, asthma in elderly patients is associated with BE in about a third of cases and these patients often have fixed airflow obstruction [39].

Mycobacterial Infection

Elderly patients in developed countries are much more likely than younger patients to have post-tubercular BE. These lesions are almost always in the upper lobes which are not a common site for other BE aetiologies. The exotically titled Lady Windermere syndrome [40] is a disorder causing nodules and BE due to Mycobacterium avian intracellulare in the middle lobe and lingula exclusively in elderly females. These ladies are classically tall and slim, sometimes have pectus excavatum and mitral regurgitation and classically have an aversion to coughing in public. Not all of these patients require treatment, but if there is progressive lung involvement and weight loss and severe systemic symptoms, they may require 18 months of therapy often including rifampicin, ethambutol and a macrolide or quinolone [41]. Some patients require augmented nutrition via PEG feeding.

Aspiration

Aspiration, like GORD, is not currently considered an important cause of BE. In the authors' opinion, this will change significantly in the next 10 years. Aspiration in elderly people is often not appreciated, but its prevalence is up to 23% in people living independently in the community > age of 70. In patients admitted with community-acquired pneumonia (CAP) over the age of 70, the prevalence of aspiration was found to be 92% compared to 40% of age-matched controls with an odds ratio of developing CAP of 11.1 [42•]. Risk factors for aspiration include cerebrovascular disease, dementia, neurodegenerative diseases, cerebral palsy and Trisomy 21, acute and chronic respiratory illnesses particularly COPD, vocal cord palsies and frailty due to sarcopenia of the swallowing muscles and decreased sensation in the oropharynx. Anybody who has performed bronchoscopy can testify to the fact that elderly patients have a much less sensitive pharynx than younger patients. Shortness of breath can cause aspiration by reducing the swallowing time, and aspiration can be seen in up to 20% of COPD patients which can predispose to exacerbations of COPD [43].

Clues to the presence of aspiration would be the following features [44]:

- Recurrent bronchitis and pneumonia
- "Wet" voice immediately after swallowing
- Coughing post-swallowing
- Piecemeal deglutition with double or triple swallow
- Self-reported pharyngeal residue post-swallowing
- ≥ 3% drop in oxygen saturation immediately post-swallowing

Oral secretions, solid food and liquid repeatedly entering the respiratory tract represent both a chemical and infectious insult to the airways and lung parenchyma. Oral hygiene is very important in these patients including usage of antibacterial mouthwash, removal of teeth with severe dental caries, fitting of properly sized dentures and treatment of oral and/or pharyngeal candidiasis. Management of aspiration depends on a number of factors. A speech and language assessment is

critical to diagnose the problem, gauge its severity and likelihood of progression. A modified barium swallow test is often performed, if the patient can comply, to determine causation and if the aspiration is modifiable by alteration of food consistency, enhanced swallowing techniques and/or head re-positioning. A nasendoscopy, or fibreoptic endoscopic evaluation of swallowing (FEES), is also a procedure that is increasingly being used to examine the nose and upper airways, while patients swallow [45].

To develop BE from dysphagia, there would usually be repeat events, often microscopic, over a significant period of time. Foreign body aspiration can also lead to BE if not diagnosed in a timely fashion, often resulting in focal BE with a middle or lower lobe distribution. Management very much depends on the underlying cause of aspiration and severity of BE. Lessening the amount of foreign material going into the lungs is always beneficial but even if the patient switches to percutaneous gastrostomy (PEG) feeding the BE once established may be self-perpetuating. The authors' choice for prophylactic antibiotic therapy is azithromycin 250 mg three times a week which anecdotally often appears to attenuate exacerbation frequency. If there is non-modifiable aspiration and stable or slowly progressive neurological disease, a PEG tube should be strongly considered.

Traction BE Secondary to Pulmonary Fibrosis

In pulmonary fibrosis, the resulting contraction of the parenchyma can pull airways out of shape although often the mucociliary apparatus functions reasonably well and clinical BE does not ensue. For that reason, it is often not included in aetiologies of BE. However, in some patients, a typical BE syndrome does develop with repeated infections and bacterial colonisation. This is most commonly seen following sarcoidosis, idiopathic pulmonary fibrosis and connective tissue disorder-associated interstitial disease. These latter two conditions frequently occur in elderly patients over the age of 70.

The Future

The authors feel that the proposed aetiologies of BE in the elderly will change over the next 10 years (Fig. 1b) The idiopathic group will shrink over time with an improved understanding of the aetiology of BE. The COPD groups will see an expansion, and aspiration will have a big overlap with post-infection causes. And there will be a large increase in the proportion of BE allocated to GORD.

As the older population grows substantially over the next decade, so will the prevalence of multi-morbidity. The pathogenesis of BE in the older person in the future will be less likely to be attributed to a solitary cause or risk factor. Instead, a multifactorial approach to causation will be adopted, whereby the cumulative effect of relatively small insults over time will result in BE. The diagnostic approach and treatment algorithms of future management will be broader, focusing on multi-modal diagnostic tools and a multidisciplinary management strategy.

Diagnosis of BE

To diagnose BE, perhaps more than other conditions, you have to have a high index of suspicion as it often complicates other conditions that also cause cough, wheeze and sputum production. Clues to the diagnosis are repeated episodes of bronchitis and pneumonia (≥ 3 per year), high sputum volume, bacterial colonisation, pronounced sputum purulence, continued sputum production in between infections and the presence of haemoptysis. Sixty-dive per cent of patients also have co-existing rhinosinusitis.

The various aetiological factors must be considered as well as a careful documentation of comorbidities. Examination must include surveillance for signs of idiopathic pulmonary fibrosis, connective tissue disorders, COPD and neurological disorders. As most BE is bi-basal, the commonest abnormalities are bi-basal coarse crackles. Clubbing is now quite rare outside of cystic fibrosis and pulmonary fibrosis. The standard laboratory work-up for BE is shown in Table 3.

Imaging Findings

Chest radiographs are not sensitive for mild to moderate BE. There are four diagnostic features on high-resolution CT thorax [46]:

Table 3 Standard laboratory work up for bronchiectasis in the older person

Standard laboratory work up for BE in the older person
Full blood count
Eosinophilia which may raise suspicion of ABPA
Lymphopenia may indicate connective tissue disease, immunosuppression due to drug treatment, HIV
Marked Lymphocytosis—? CLL
Serum IgE Typically > 1000 U/L in ABPA
Serum Immunoglobulins IgG[a], IgA, IgM
Aspergillus IgG, IgE
Sputum analysis (see text)
Alpha-1 antitrypsin deficiency—not routinely performed
Sweat test and CF genotyping—very rarely performed in the elderly
Primary ciliary dyskinesia—very rarely performed in the elderly

[a] Some centres do IgG subclasses. Our own institution checks antibody levels to *Haemophilus influenzae* B, pneumococcus and tetanus and if these functional antibodies are low, they are retested 6 weeks after vaccination

1. Internal diameter of the airway > diameter of the accompanying blood vessel (signet ring sign)
2. Failure of the airway to taper as it travels peripherally (best seen in middle lobe/lingula)
3. Visible airways within 1 cm of the pleura
4. Crowding of the airways (due to peri-airway scarring causing contraction of the lung parenchyma)

Cylindrical BE describes dilated airways alone and is often the post-infective BE pattern. Varicose BE is where the dilated airway have focal constrictions with a "varicose vein-like" appearance. The most severe form of BE is the saccular type where the airways lose all wall structure and resemble large cysts, and there may be fluid levels within them [1].

It is also very important to look at the expiratory HRCT images for dynamic airway collapse and also review the mediastinal windows for a hiatus hernia.

Sputum Analysis

It is important to determine whether patients have a particular organism during an acute exacerbation to guide treatment although sometimes, this maybe a commensal organism. Repeated positive sputum cultures with the same organism may also suggest colonisation. It is particularly important in the elderly and females to also send sputum for acid-fast smear and mycobacterial culture. The presence of *Pseudomonas aeruginosa* and *E. coli* bacteria should always raise suspicion for BE in patients with other respiratory diagnoses and potentially prompt a dedicated work up including HRCT if appropriate.

Pulmonary Function Tests

Guidelines suggest baseline spirometry, reversibility if obstruction present and gas transfer. Spirometry should be repeated annually in patients in secondary care [5]. Eighty per cent of patients with BE will have an obstructive picture on pulmonary function testing. Reduced gas transfer can suggest coexistent emphysema or fibrosis.

Treatment

The main goals of treatment of BE are to reduce symptoms, prevent exacerbations, treat acute exacerbations adequately and attenuate disease progression. We have already touched on the treatment of a number of aetiologies more specific to the elderly above.

Non-Pharmacological

Airway Clearance

Achieving good airway clearance is essential to reduce symptoms and exacerbation frequency. The most common techniques employed are listed below. Efficacy appears to be similar with all techniques. Patient preference and adherence to treatment are key factors that should be considered when selecting the technique.

- Active cycle of breathing technique (ACBT)—the patient performs breathing control exercises, interspersed with thoracic expansion exercises, and completes the cycle with the forced expiratory technique (commonly known as the Huff). The BTS guidelines for non-CF BE (2010) recommend that ACBT be considered for all patients [5]. Results from the EMBARC database (2016) showed 55% of BE patients use ACBT as their airway clearance technique of choice [47].
- Autogenic drainage (AD)—a series of breathing exercises to attain the highest possible expiratory flow to move secretions from peripheral to central airways without forced expirations and airway closure [48]
- Oscillation devices—most commonly used devices are Acapella® and Aerobika®; the patient blows into a device which vibrates and causes some end expiratory pressure and this creates back pressure oscillation waves into the airways and helps to loosen mucus [49]
- Positive expiratory pressure (PEP) masks—a technique that applies a positive pressure to the airways during expiration. This helps to maintain airway integrity in patients who get marked dynamic expiratory collapse which traps the mucus in the airways [50]. PEP therapy does not generate the expiratory flow necessary to mobilise the secretions proximally; therefore, it needs to be combined with a forced expiratory technique [51].
- Non-invasive ventilators can also be used as an adjunct to airway clearance.

Specific issues with older populations that can impact on airway clearance are sarcopenia resulting in reduced inspiratory and expiratory muscle strength. If there is severe airflow obstruction present, the cough peak flow could be very low and cough fractures could be more common due to osteoporosis and can take up to 6 to 8 weeks to heal. Cognitive impairment can also interfere with sputum clearance as patients either forget to do sputum clearance or resist the process.

Pulmonary Rehabilitation

A structured 6–8 week programme combining aerobic and strength training exercise and education. It can significantly

help shortness of breath if present, quality of life and improve exercise capacity [52].

Physiotherapy for Urinary Incontinence

This affects a high number of females and occasionally males and worsens with age. This is rarely mentioned by the patient themselves, and direct questioning is usually required to see if there is an issue. Patients often get considerable improvement by performing the "knack" technique [53]. This is a counterbracing technique, taught by clinicians or physiotherapists, to prevent leakage during increases in abdominal pressure. The patient is taught to contract the pelvic floor muscle just prior to physical stresses such as coughing or sneezing.

Dietetics

Patients with repeated infections can become significantly underweight, and this in turn can negatively affect their immune system and muscle strength. Calorie supplementation may be critical in some patients, and this may include overnight peg feeding in extremely underweight patients.

Pharmacological Therapies

1. Yearly influenza vaccination
2. Once-off pneumococcal vaccination once > age 65 and at least 10 years post previous pneumococcal vaccination
3. Mucolytic therapy—if the patient has tenacious mucus, the following treatments may be beneficial:
   (a) Oral carbocysteine
   (b) Nebulised 0.9% saline to hydrate the airway
   (c) Hypertonic saline—should be used initially under strict observation as this can cause significant bronchospasm and airway inflammation
   (d) Inhaled anti-muscarinic therapy can sometimes lead to very tenacious mucus production and a trial off this therapy is sometimes warranted
4. Inhaled corticosteroids may be helpful for co-existing diagnoses of asthma or COPD and has been shown to reduce sputum volume in patients colonised with *Pseudomonas aeruginosa*
5. Inhaled bronchodilators such as short- and long-acting beta agonists and anti-muscarinic agents may also improve symptoms of dyspnoea and sputum clearance in patients with BE

A positive bronchodilator response (BDR) at baseline is independently associated with responsiveness to long-term bronchodilator therapy in bronchiectasis patients with airflow limitation. However, FEV_1 improvement has also been shown in BE patients without a positive baseline BDR, suggesting these patients can benefit from long-term bronchodilator therapy.

Compliance with inhaled therapy is often suboptimal in older patients; this can be due to physical difficulties with using devices, reading the instructions and cognitive deficits in areas such as memory and executive function. It is essential to regularly assess inhaler technique and try several devices with the patient to ensure that they can understand and use the device easily. In some patients, it is critical that a relative or healthcare assistant supervises their inhalers for every dose.

Antimicrobial Therapy

Acute Exacerbations

These should be promptly treated with antibiotics, the choice of which should be based on previous sputum m**ic**robiology when possible. The route of administration depends on the organism and its antibiotic susceptibilities. The mantra is that we should treat with twice the standard dose of antibiotics for twice as long [5]. The most common organisms that require treatment are seen in Table 4 and the recommended antibiotic. In patients with *Pseudomonas aeruginosa* that is resistant to ciprofloxacin, it would be unusual in elderly patients, due to potential nephrotoxicity and ototoxicity, to employ synergistic intravenous therapy with aminoglycosides as well. In older

Table 4 Antibiotic choices for the most common bacteria witnessed in bronchiectasis exacerbations

Haemophilus influenzae	Amoxicillin 1 g tds, co-amoxiclav 625 mg tds, doxycycline 100 mg bd po for 14 days
Streptococcus pneumonia	Amoxicillin 1 g tds, co-amoxiclav 625 mg tds, doxycycline 100 mg bd po for 14 days
Moroxella catarrhalis	Co-amoxiclav 625 mg tds, doxycycline 100 mg bd po for 14 days
Staphylococcus aureus	Flucloxacillin 1 g qds, doxycycline 100 mg bd po for 14 days
Pseudomonas aeruginosa	Ciprofloxacin 750 mg BD po for 14 days, Tazobactam 4.5 g tds IV, Meropenem 1 g tds IV, Ceftazidime 2 g tds IV for 14 days
Coliforms	Co-amoxiclav 625 mg tds, Ciprofloxacin 750 mg bd po for 14 days
Stenotrophomonas maltophilia	Co-trimoxazole 960 mg bd po for 14 days

patients, potential complications of treatment include *Clostridium difficile* infection (quinolones and clindamycin are avoided as much as possible), Achilles tendonitis from quinolones, bacterial overgrowth and malabsorption syndrome.

Eradication Therapy

Colonization with bacteria is a frequent complication of BE. *Pseudomonas aeruginosa* is common in severe BE and is associated with a more severe phenotype with more rapid deterioration in lung function, greater hospitalisation and a worse prognosis. On first sputum culture of *Pseudomonas aeruginosa*, many centres would institute an attempted eradication regime. Examples of this would be long-term inhaled colistin [54, 55], 8 weeks of high-dose oral ciprofloxacin, 2 weeks of intravenous anti-pseudomonal therapy alone or followed by a further 3 months of ciprofloxacin or inhaled tobramycin [56] or colistin. It is important to counsel patients regarding sings of tendonitis and avoid the coexistent use of steroids where possible to reduce the risk of adverse events.

Prophylactic Antibiotics

If there are ≥ 3 exacerbations in the previous 12 months, despite regular sputum clearance, this is an indication for long-term antimicrobial prophylaxis. First-line therapy is usually a macrolide antibiotic such as azithromycin [57] or, less commonly, clarithromycin if there are no contraindications. Macrolides have both antibiotic and anti-inflammatory properties. The most common doses employed in BE is 250–500 mg three times a week 30 min before food. Side effects are rare and mostly consist of slightly loose motions on the day of ingestion. In the elderly population, the most worrying side effect is a permanent reduction in hearing [28]. Development of *Clostridium difficile* is very rare and although drug resistance in upper airway organisms has been identified, this did not translate into life-threatening lower respiratory tract infections. Doxycycline 100 mg once daily is the authors' second choice of prophylactic antibiotic.

Prophylactic inhaled antibiotic therapy in those colonised with *Pseudomonas aeruginosa* is also widely used. Inhaled colistin [58], tobramycin [59], aztreonam [60] and ciprofloxacin [61] are all available and can be used in an alternating fashion. Patients have to be trialled with these antibiotics to be sure they do not develop severe bronchoconstriction.

Surgery/Lung Transplantation

Surgery is an option for patients who have very localised disease, often the right middle lobe, or who have a relatively small focus of a very resistant organism, for example, multi drug-resistant tuberculosis. These patients would have to have reasonable lung function and decent cardiac status. Lung transplantation for BE is always a bilateral procedure as you cannot leave a septic lung behind in the face of immunosuppression. The absolute upper age limit for this operation is 65 years; therefore, this does not apply to the very elderly with BE. Finally, bronchoscopy may be required for the assessment of localised BE or for the removal of foreign body/tumour causing an obstruction.

Conclusion

With an ageing population, BE is increasing in prevalence, both due to the progression of pre-existing diseases developed at an earlier age and also the development of specific elderly-related conditions cumulating in BE. The natural ageing process leads to the development of GORD, immunosenescence, interstitial lung diseases with traction BE and aspiration.

Other factors include more aggressive treatment of elderly patients for malignant and inflammatory conditions with potent immunosuppression. In later life, patients with long-standing COPD and asthma may also frequently develop coexistent BE. Elderly patients, because of co-morbidity and frailty, are more likely to be hospitalised with exacerbations and require intravenous antibiotics. In both the BSI and FACED mortality scores, age is an independent risk factor for death.

It is unclear how much can be achieved in terms of reducing the risk of developing BE in elderly people and/or slowing down its progression. Widespread access to vaccination is important. Better diagnosis and management of COPD is critical; this should also include a heightened awareness/suspicion for coexistent BE. GORD is a significant cause and cofactor in the development of BE. Physicians should be able to identify patients with an increased risk of aspiration in the elderly population, and there should be a significant expansion in the ability of healthcare professionals to perform basic swallowing assessments.

Compliance with Ethical Standards

Conflict of Interest The authors declare no conflicts of interest.

Human and Animal Rights This article does not contain any studies with human or animal subjects performed by any of the authors.

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