MDCT findings of the upper and the lower airway diseases in the elderly

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Objectives

- To provide an overview of the possible spectrum of airway diseases in the elderly.
- To illustrate the imaging findings helpful in differential diagnosis.
- To emphasize the role of imaging modalities in diagnosis, staging and follow-up of these disorders.
The prevalence of airway diseases increases with age. The elderly are at greater risk of developing them because of their frailty and long-term exposure to smoking, air pollution, work exposure and infections. Declining fertility rates and improved health and longevity have swelled the older populations dramatically, at an unprecedented rate (Fig. 1 on page 15). By 2050, the United Nations estimates that the population aged 60 or over is projected to increase nearly threefold to reach 2 billion and Europe will continue to be the world's oldest region [1]. Owing to this demographic trend, physicians have to face more frequently elderly patients, often malnourished and immunocompromised, more prone to develop severe complications.

Although airway diseases are very common in the elderly, they are often overlooked and untreated. This is due to the lack of specific symptoms, the presence of co-morbidities and the use of several therapies, which could mask the single entities.

The airways are classically divided into upper and lower, as diseases that affect them (Table 1 on page 15). Lower airway disease includes COPD, bronchiectasis, asthma and bronchiolitis, which are very common among older patients and well-known. On the other hand, upper airway disease (UAD) consists of an heterogeneous group of disorders which often remain undiagnosed and untreated. We will focus on the more common entities which affect the elderly, giving radiologists the opportunity to become more aware of these disorders so as to allow a proper treatment.

The first step in the evaluation of airway disease is usually represented by chest radiography (CXR), but the involvement of the airways may be unapparent or missed. As elderly are often unable to tolerate conventional bronchoscopy, multidetector computed tomography (MDCT), with multiplanar reconstructions (MPR) and 3D images (VR images), is currently the best imaging technique for the assessment of the airway diseases: in particular, MDCT allows detection, differential diagnosis, staging of neoplasms, accurate pre-treatment evaluation and follow-up.

**UPPER AIRWAY DISEASE**

UAD may be classified into neoplastic and nonneoplastic (Table 1 on page 15). The former may be benign or malignant, whereas the latter may be distinguished into focal or diffuse, according to the extension of the lesion. In the elderly the most common focal diseases, which cause a narrowing of a single region of the airway lumen, include post-intubation stenoses, post-infectious stenoses and tuberculosis. Conversely, diffuse diseases involve a long segment of the airway or have multiple foci and may cause enlargement or narrowing of the airway lumen.
Diffuse diseases enlarging the airway lumen include tracheobronchial diverticula and tracheobronchomegaly, whereas disorders which determine a luminal narrowing include "saber-sheath" trachea deformity, tracheobronchomalacia, bronchial anthracofibrosis, relapsing polychondritis, tracheobronchopathia osteochondroplastica, tracheobronchial amyloidosis and Wegener's granulomatosis.

**Nonneoplastic tracheobronchial disease**

![Table 2: Classification of nonneoplastic upper airway disease in the elderly](image)

**References:** CATHOLIC UNIVERSITY OF SACRED HEART - ROME/IT

**Focal diseases**

- **POST-INTUBATION TRACHEAL STENOSIS**

The placement of endoluminal tubes in the large airways may cause a reparative fibrotic process at the cuff site (in tracheal intubation) or at the stoma site (in tracheostomy), leading to a tracheal narrowing [2]. Iatrogenic stenoses are usually focal, 1.5-2.5 cm in length, showing a concentric soft tissue thickening of the internal mucosa, less frequently
eccentric (Fig. 2 on page 16) [3]. CXR often does not reveal the tracheal stenosis, as it usually lies on the upper edge of the radiograph [4]. On CT longitudinal images, the focal narrowing may produce a typical "hourglass" configuration (Fig. 2 on page 16) [2].

**POST-INFECTIOUS TRACHEAL STENOSIS AND TUBERCULOSIS**

Although post-infectious strictures may be caused by different pathogens, *Mycobacterium tuberculosis* represents the main cause.

The elderly are at a greater risk for re-activation of latent tuberculosis and for the acquisition of new infection of *Mycobacterium tuberculosis*. Central airways may be involved in 10-40% of cases of pulmonary parenchymal tuberculosis, by lymphatic spread or local invasion from mediastinal affected lymph nodes (Fig. 3 on page 17) [4]. The most frequent site of stenosis is the lower third of the trachea and the main stem bronchi. The strictures are more commonly focal than diffuse, concentric and usually 3 cm in length. MDCT findings tend to reflect the stage of disease, differentiating the active phase, characterized by an irregular thickening of tracheal wall (due to inflammatory edema), from the fibrotic phase, in which the tracheal narrowing shows a smooth and normally thick wall (Fig. 3 on page 17).

In case of post-infectious tracheal stenosis, axial images may overlook subtle stricture and underestimate its cranio-caudal extent. Thus, MPR and VR images are essential for an accurate evaluation of the site and the length of stenosis [5], for treatment planning and subsequent follow-up.

**Diffuse diseases**

**TRACHEOBRONCHOMEgALY**

Tracheobrochomegaly is characterized by marked dilation of the trachea and main stem bronchi: transverse and sagittal diameters of the trachea exceed 25 and 27 mm respectively, whereas the left and right main stem bronchi diameter exceed 18 or 21 mm respectively, in men. In women, the respective diameters are 21, 23, 17.4 and 19.8 mm. CXR shows dilation of the trachea and main bronchi. Nevertheless, CT better demonstrates the frank airway dilation and may also reveal tracheobronchial diverticula, central bronchiectasis and the possible causes of tracheobronchomegaly, such as emphysema or fibrosis of the upper lobes (Fig. 4 on page 17).

**TRACHEOBRONCHIAL DIVERTICULA**

Tracheobronchial diverticula usually represent an incidental finding in chest CT scans [6]. The typical patient is elderly and asymptomatic, even though diverticula could undergo complications, such as wall inflammation, perforation and pneumomediastinum.
Tracheobronchial diverticula may be congenital or acquired. The former are usually very small, with a very narrow communication with the airway (Fig. 5 on page 18), whereas the latter are bigger and usually have a wide communication with the airway (Fig. 6 on page 19)[6].

On CT scans, diagnosis of air paratracheal cysts requires determining whether their origin is tracheal or not. Differential diagnosis includes Zenker's diverticulum, pharyngocele, laryngocele, apical lung hernia and bullae due to paraseptal emphysema. MDCT allows the visualization and the characterization of the lesion (location, size, number, origin, diverticula neck size, association with other pulmonary findings such as chronic obstructive pulmonary disease - COPD). MPR and VR reconstructed images better depict the relationship between the tracheal lumen and the air cyst in most cases (Fig. 5 on page 18)(Fig. 6 on page 19). In case of complications, MDCT represents an important tool for management of patients.

- "SABER-SHEATH" TRACHEA

"Saber-sheath" trachea deformity is very common in advanced age. It almost exclusively occurs in males with COPD, of which represents a pathognomonic sign. This deformity is characterized by a severe reduction of the coronal diameter and an increase in the sagittal diameter, with a sagittal-to-coronal diameter ratio exceeding 2:1. The extrathoracic trachea is normal in diameter. CXR shows diffuse narrowing of the intrathoracic trachea on the postero-anterior view (Fig. 7 on page 20). CT scans may depict an inward bowing of the lateral tracheal walls, due to cartilage weakness, which may be accentuated on the expiratory scans (Fig. 7 on page 20).

- TRACHEOBRONCHOMALACIA

Tracheomalacia refers to a higher trachea susceptibility to collapse. Although it may be congenital or acquired, the middle-aged and the elderly are mostly affected by the acquired forms. Tracheomalacia may be localized to one portion of the trachea, or may involve the entire trachea, extending sometimes into the main stem bronchi (tracheobronchomalacia). MDCT is considered the best imaging tool for accurate qualitative and quantitative analyses of the tracheobronchial lumen collapse, representing a valuable alternative to bronchoscopy in the elderly. As TBM escapes detection on standard end-inspiratory MDCT scans, diagnosis usually requires airway assessment after a forced expiration (static expiratory scan) or during an active respiratory manoeuvre (such as forced exhalation or coughing). The coughing manoeuvre should be recommended in older patients, because of their difficulty to perform effective forced expiratory scans. A hallmark of TM is the "frown sign", a crescent bowing of the posterior membranous tracheal wall at expiratory CT scans (Fig. 8 on page 21). The quantitative method for assessing airway collapse consists of electronic tracing of a cross-sectional area of the airway lumen at the same level in inspiratory and expiratory scans: a reduction of 50% in cross-sectional luminal areas is the current...
diagnostic criterion, although recent studies recommend a cut-off of 70-80% on forced expiration [2].

- **BRONCHIAL ANTHRACOFIBROSIS**

**Bronchial anthracofibrosis** is a benign condition only recently defined, affecting more frequently elderly women. The term refers to the bronchoscopic finding of dark anthracotic pigments in the bronchial wall, with subsequent bronchial narrowing or obliteration, in patients without a relevant history of pneumoconiosis or smoking [7]. The most commonly reported finding on CT scans is lobar or segmental post-obstructive atelectasis. Multifocal stenoses of lobar and segmental bronchi with peribronchial soft tissue thickening and calcified or noncalcified lymph nodes may also be seen (Fig. 9 on page 22).

- **Less common disorders**

**Relapsing polychondritis** is a multisystem autoimmune disease characterized by recurrent inflammation of cartilage, which lead to cartilage destruction and fibrosis [4]. CT is essential in evaluating the respiratory tract involvement, as tissue samples are very difficult to obtain through bronchoscopy, which could encounter insurmountable obstacles and even exacerbate the inflammation [8]. CT scans demonstrates more commonly expiratory abnormalities (air trapping and malacia) than inspiratory anomalies (such as airway calcifications, smooth wall thickening, airway narrowing). The posterior tracheal wall is typically spared (Fig. 10 on page 23). Both extrathoracic and intrathoracic trachea are involved.

MDCT with MPR images is particularly useful for planning interventional procedures (stent placement, ballon dilatation) and in surveillance of patients undergoing pharmacologic therapy (anti-inflammatory and immunosuppressive drugs).

**Tracheobronchopathia osteochondroplastica** is often asymptomatic, thus diagnosis is incidental during a bronchoscopic exam. CXR is aspecific in many cases, whereas MDCT represents an important non-invasive diagnostic tool, as it may reveal numerous submucosal sessile cartilaginous or bony nodules (3-8mm), protruding into the tracheal lumen from the antero-lateral walls (Fig. 11 on page 24), sparing the membranous posterior wall (a typical sign) [3].

Tracheobronchopathia osteochondroplastica more frequently involves the trachea and main stem bronchi or the lower tract of the trachea, whereas the main bronchi are rarely affected.

**Tracheobronchial amyloidosis** usually demonstrates diffuse involvement of the tracheobronchial tree, beginning from the trachea and large bronchi, extending sometimes to segmental bronchi (Fig. 12 on page 25). MDCT clearly depicts a multifocal, nodular or circumferential wall thickening of soft-tissue density with a smooth surface and possible concentric calcifications even in the posterior wall membrane,
cartilaginous ossifications in absence of malacia and post-obstructive pulmonary complications (Fig. 12 on page 25) [3]. The stricture, due to infiltration of all layers of the airway wall, is often resistant to medical therapy, thus a stent placement is necessary to recover the airway patency. MDCT is a valuable non-invasive imaging tool for evaluating the correct position and the patency of the stent placed (Fig. 13 on page 26).

Tracheobronchial involvement in patients with **Wegener's granulomatosis** often represents a late complication of the disease [8]. At MDCT a focal or, more often, diffuse circumferential wall thickening, concentric or eccentric, approximately 2.5 cm in length may be shown. MDCT also allows the evaluation of lung parenchyma, which frequently presents parenchymal nodules (often cavitated), airspace consolidations, pleural effusion or lobar/segmental atelectasis [8].

**DIFFERENTIAL DIAGNOSIS**

In nonneoplastic disorders, firstly it is important to distinguish between focal and diffuse forms, then presence of calcifications, type of wall thickening and sparing of the posterior wall may be helpful in differential diagnosis (Table 3 on page 27).
In the elderly tracheobronchial neoplasms are most commonly malignant and primitive. Approximately two-thirds of primary tumors are represented by squamous cell carcinoma and adenoid cystic carcinoma, whereas the remaining third is distributed widely in a heterogeneous group of malignant and benign tumors. CXR has a very low sensitivity in the identification of tracheal neoplasms. Bronchoscopy allows tissue sampling, but it is unable to clearly distinguish the extent of disease and often it is not tolerated by elderly patients. Conversely, MDCT allows a non-invasive evaluation of the tumor extent and lymph nodes involvement and may demonstrate metachronous/synchronous lesions and pulmonary metastases. Moreover, VR images provide an accurate road map of the central airways (CT bronchography) and a simulation of endoscopic navigation through the tracheobronchial tree (virtual bronchoscopy), that result more familiar to surgeons and bronchoscopists than axial images [9]. Thus, MPR and VR images represents a non-invasive alternative to the conventional method in elderly patients and are very useful in treatment planning and during follow-up.

- Malignant tumors
Squamous cell carcinoma is the most common primary tracheobronchial tumor in the elderly. At MDCT it may appear as a focal sessile or polypoid mass of soft tissue density, an eccentric narrowing of the airway lumen (Fig. 14 on page 28) or a circumferential wall thickening [10]. About 30% of patients have mediastinal or pulmonary metastases at presentation time. Moreover, metachronous or synchronous lesions involving lungs, larynx or oropharynx are present in 40% of cases.

Adenoid cystic carcinoma represents the second most common primary tracheobronchial malignancy. It typically arises from the lower trachea, main and lobar bronchi. It grows slowly and rarely has regional lymph node metastases. At MDCT scans, adenoid cystic carcinoma may manifest as an intraluminal mass of soft-tissue attenuation with extension through the tracheal wall (Fig. 15 on page 29) or a diffuse wall thickening of the trachea. Early recognition may improve surgical resectability and patient prognosis.

Mucoepidermoid carcinoma is rare. It usually manifests at CT as an intraluminal nodule (Fig. 15 on page 29), which may cause post-obstructive atelectasis, particularly when the tumor is located in the segmental bronchi.

Secondary involvement of the tracheobronchial tree may occur, resulting more frequently by direct invasion of tumors of the nearby structures (i.e. thyroid, esophagus, mediastinum, lung and larynx) rather than by hematogenous metastases.

**Benign tumors**

Benign tumors of the tracheobronchial tree are rare, especially in the elderly. In this subset of population the most common types include hamartomas, lipomas and papillomas. They are usually small (< 2cm), polypoid, round, sessile intraluminal masses with smooth margins and without involvement of adjacent structures. In particular, on CT scans hamartomas appear as a heterogeneous soft-tissue mass with fat collections (Fig. 16 on page 30), sometimes alternating with foci of calcification (“popcorn” calcification). Conversely, lipomas usually show a typical attenuation value of fatty tissue (-100 UH), an homogeneous soft-tissue density with and without contrast enhancement (Fig. 16 on page 30). CT is highly specific and sensitive in the detection of fat and can provide a definite diagnosis of these entities [7]. Solitary squamous cell papillomas, due to human papillomavirus infection, on CT scans appear as mucosal nodules protruding into the tracheal lumen, which can produce distal obstructive pneumonia and atelectasis.

**LOWER AIRWAY DISEASE**

Chronic obstructive pulmonary disease (COPD), bronchiectasis, asthma and bronchiolitis represent the most common lower airway diseases in the elderly (Table 1). Airflow obstruction, either reversible or irreversible, is the main feature of these disorders.
COPD

COPD has been described by the GOLD, the American Thoracic Society (ATS) and the European Respiratory Society (ERS) as a condition characterised by airflow limitation that is not fully reversible [11]. The airflow limitation, in most cases, is progressive and associated with an abnormal inflammatory response of the lungs to noxious particles or gases.

The airflow limitation is caused by loss of elastic recoil of the lung emphysema and chronic inflammation followed by remodeling of small airways. According to the prevalent contributor, three groups of patients or phenotypes may be identified: emphysema-predominant, airway-predominant and mixed phenotype [12].

CXR can be considered an initial tool for assessing COPD. Signs of hyperinflation of the lungs (flattening of hemidiaphragms and widening of retrosternal and retrocardiac spaces), in association with radiolucent areas, due to attenuation or absence of pulmonary vasculature or loss of regular vascular branching pattern, represent findings that lead to a radiologic suspicion of pulmonary emphysema (Fig. 17 on page 31). On the other hand, findings of pure airway diseases are not specific and consist of bronchial wall thickening that gives rise to the so-called "dirty lung" appearance at CXR but, as previously mentioned, it can also be related to paraphysiologic modifications of elderly patients' airways. CT imaging is the most useful tool in diagnosing COPD in living patients and it has a potential role in "phenotyping" the disease, whereas clinical markers of airway inflammation, static or dynamic lung function tests and symptoms are indistinguishable among patients with a prevalent emphysematous phenotype and airway phenotype [12]. CT allows the assessment of presence, location and extent of pulmonary emphysema with a high degree of pathologic correlation. On CT scans, emphysema is characterized by abnormally low attenuation areas with a density threshold of -950 HU. Air trapping, defined as persistent parenchymal areas of less than normal lung attenuation associated with lack of lung volume reduction on expiratory CT scans, may be identified on expiratory images in COPD patients, representing airflow obstruction.

Recognition of COPD predominant phenotype may allow individualized patient treatment and disease surveillance. In emphysema-predominant phenotype, automated software allows the segmentation of each pulmonary lobe and quantification of the amount of emphysema within each single lobe (Fig. 18 on page 32). This process is helpful in selecting candidates for surgical therapy (lung-volume reduction surgery, bronchoscopic lung-volume reduction, bullectomy, transplant).

Centrilobular nodules, linear opacities with a look at "flowering tree", areas of increased density appearance with "ground glass" and consolidations are due to pulmonary superinfection.
• **BRONCHIECTASIS**

Bronchiectasis is defined as localized or diffuse bronchial dilatation resulting in dilated and usually thick-walled airways, typically visualized until the lung periphery. In the elderly, immunodeficiency and ineffectiveness of mucociliary clearance with accumulation of secretions, may lead to recurrent insults to the airway wall with subsequent bronchial wall inflammation, fibrosis and distortion [13]. High resolution computed tomography (HRCT) imaging is the method of choice for examining patients with suspected bronchiectasis, as it is more sensitive than CXR (Fig. 19 on page 33). CT findings of bronchiectasis include bronchial dilatation and bronchial wall thickening.

Bronchiectasis is classified on the basis of the gross pattern of bronchial dilatation as cylindrical, varicose or cystic.

**Cylindrical** bronchiectasis occurs when the bronchus is larger than the adjacent pulmonary artery (signet-ring sign - Fig. 20 on page 34) or when the bronchus is lacking its typical "tapering" aspect towards the periphery and is visible at the peripheral portions of the lung, within 1 cm from the pleura [13].

**Varicose** bronchiectasis is characterized by beaded bronchial dilatation and it can be accurately demonstrated when the bronchus is cut longitudinally in the plane of the CT section.

**Cystic** bronchiectasis is defined as bronchial dilatation greater than 1 cm and is usually clustered as cysts. Cystic bronchiectasis may have an important role in elderly patients because it leads to more extensive bronchial destruction than cylindric bronchiectasis and is typically associated with more severe clinical symptoms.

CT findings commonly associated with bronchiectasis include decreased lung attenuation distally to the affected bronchi, assumed to represent air trapping (Fig. 20 on page 34), bronchial mucoid impaction and atelectasis.

• **ASThma**

Asthma is characterized by a reversible obstruction of airways due to bronchial hyper-responsiveness associated with airway inflammation involving both proximal and distal airways. However, chronic inflammation and subsequent repair processes can lead to irreversible changes.

Asthma is a highly prevalent disease in the general population, as well as in the elderly but it is less commonly recognized as a geriatric respiratory disease, due to a cultural bias that associates the disease with childhood and adolescence.
HRCT abnormalities in asthmatic patients consist of bronchial wall thickening, bronchial dilatation/bronchiectasis, mucoid impaction and a "mosaic" appearance of the lung parenchyma.

Automated measurement of airway parameters (lumen area, inner and outer diameters, wall thickness and wall area), obtained using dedicated software, may demonstrate significant changes of bronchial morphometry in inspiratory and expiratory scans and predict the presence of airflow limitation and airway remodeling in asthma [14].

**BRONCHIOLITIS**

The term bronchiolitis refers to a broad spectrum of inflammatory and fibrotic pulmonary diseases centered on the small conducting airways (Visscher and Myers 2006). The most common types of bronchiolitis in the elderly are aspiration and infectious bronchiolitis.

HRCT findings include direct and indirect signs of small airway diseases. Direct signs of bronchiolitis consist of solid or ground glass centrilobular nodules and tree-in-bud opacities [15, 16] (Fig. 21 on page 35). Conversely, mosaic attenuation and air trapping are indirect signs of small airway diseases [16].

**Aspiration Bronchiolitis**

Diffuse aspiration bronchiolitis is characterized by a chronic inflammatory reaction to recurrent aspiration of gastric contents or foreign bodies in the bronchioles, very common in the elderly.

CXR reveals diffuse, unilateral or bilateral, small (<5 mm) nodular opacities.

On HRCT, the most frequent appearance is tree-in-bud opacities associated with adjacent areas of lobular consolidation. The distribution of these findings follows the patient’s decubitus. In particular, abnormalities predominantly involve the posterior portion of the upper and lower lobes in bedridden patients [16].

**Infectious Bronchiolitis**

Infectious bronchiolitis may occur in immunocompromised individuals, as the elderly often are. It has been observed in various infections including viral, bacterial and mycobacterial infections.

CXR may show bilateral, often subtle, nodular, or reticular opacities. Partial small airway obstruction may manifest as hyperinflation. On HRCT, infectious bronchiolitis typically shows well-defined centrilobular nodules and tree-in-bud opacity [16](Fig. 21 on page
35). These findings may be patchy and unilateral or bilateral and asymmetric and do not follow patient decubitus [15].
Images for this section:

Fig. 1

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**Table 1:** Classification of airway disease in the elderly

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**POST-INTUBATION TRACHEAL STENOSIS** in a 70-yr old man

![Image of CT scan showing post-intubation tracheal stenosis](image-url)
Fig. 2: Axial non-enhanced CT image at mediastinal window setting (a) shows an eccentric stenosis of the sub-glottic tracheal lumen on the right (arrow). External VR image (b) along the long axis of the trachea better depicts the stricture extent and the typical appearance of "hourglass" of the trachea.

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Fig. 3: Axial non-enhanced CT images at mediastinal window setting (a,b) show enlarged lymph nodes (arrows) in the right paratracheal region and subcarinal region that infiltrate distal trachea and right main bronchus walls, determining airway lumen narrowing. Coronal CT reformation at lung window setting (c) and VR image (d) better illustrate the extension of the lesions throughout the tracheobronchial tree.

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**Fig. 4:** Axial CT images at lung window setting show severe dilatation of the trachea (a) and the right main stem bronchus (b) associated with fibrotic consolidations and traction bronchiectasis in the upper lobes, more evident on the right (a).

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Fig. 5: CONGENITAL DIVERTICULUM. Axial CT image at lung window setting (a) show an air-filled right paratracheal cyst (arrow) at the cervico-thoracic junction. Coronal MPR image at lung window setting (b) better depicts the apparent communication (arrow) with the tracheal lumen by a narrow neck.

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Fig. 6: ACQUIRED DIVERTICULUM. Axial CT image (a) and oblique MPR image (b) at lung window setting show a large air-filled paratracheal cyst (arrow) at the cervico-thoracic junction. The large dimension and the broad base are consistent with an acquired diverticulum.

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Fig. 7: Chest X-Ray postero-anterior view (a) shows a narrowing of the transverse diameter of the intrathoracic trachea. Axial CT images at lung window setting (b,c) depict an inward bowing of the lateral tracheal walls, accentuated on the expiratory scan (c).

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**Fig. 8:** Axial inspiratory CT images at lung window setting (a,b) show a normal shape of the tracheal and bronchial lumen. Expiratory CT images at lung window setting (c,d) demonstrate a severe collapse of the airways with an inward bowing of the posterior wall ("frown" sign). Mild air-trapping is also evident in both lungs.

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**BRONCHIAL ANTHRACOFIBROSIS**

**Fig. 9:** Axial contrast-enhanced CT scan at mediastinal window setting (a) shows partial atelectasis of right upper lobe with smooth narrowing of right main bronchus and obstruction of right upper lobe bronchus. An enlarged lymph node (arrow) adjacent to involved bronchus can be seen. Axial non-enhanced CT scan at mediastinal window setting (b) shows obstructed right middle lobe bronchus resulting in partial atelectasis of right middle lobe. Calcified lymph nodes adjacent to right middle lobe bronchus are also present (black arrows). Lingular segmental bronchus is thickened with adjacent enlarged lymph nodes containing calcification (white arrow).

Fig. 10: Axial CT images at mediastinal window setting show smooth tracheal (a) and bronchial (b) wall thickening with calcifications. The typical sparing of the posterior membranous walls of the airways can be seen (arrows).

Fig. 11: Coronal CT reformation show a diffuse stricture of the tracheal lumen due to an irregular thickening of the lateral walls.

Fig. 12: Axial CT images at mediastinal window setting (a,c) show diffuse, circumferential and smooth wall thickening with mild calcifications of the trachea, main stem bronchi and lobar bronchi bilaterally. Axial image at lung window setting (b) demonstrates an almost complete occlusion of the right upper lobar bronchus with a distal chronic post-obstructive atelectasis of the anterior segment of the right upper lobe (arrow).

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Fig. 13: Axial CT image at mediastinal window setting (a) shows the patency of the tracheal stent placed into a circumferential thickening of the tracheal wall, due to amyloidosis. Sagittal MPR image at mediastinal window setting (b) confirms the airway patency and better depicts the entire location of the stent.

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Table 3: Key findings in differential diagnosis of nonneoplastic diffuse upper airway disease

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Fig. 14: Chest X-Ray postero-anterior view (a) shows an upper right paratracheal opacity narrowing the tracheal lumen (arrow). Axial enhanced-CT image at mediastinal window setting (b) confirms the eccentric lobulated soft tissue mass that origins from the right antero-lateral tracheal wall and narrows the lumen of the upper trachea. Coronal MPR image at mediastinal window setting (c) better depicts the entire extent of the lesion.

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Fig. 15: Axial CT scan at mediastinal window setting (a) shows an irregular thickening of the left tracheal wall with a lobulated mass protruding into the tracheal lumen (arrow). Axial CT scan at mediastinal window setting (b) demonstrates irregular thickening of the left postero-lateral tracheal wall with nodular intraluminal extension of tumor (arrow).

**Fig. 16:** Axial contrast-enhanced CT scan at mediastinal window setting (a) shows a low-attenuation (-5 HU) endobronchial nodule (black arrow) in the bronchus intermedius. Post-obstructive atelectasis of the right lower lobe can be seen (white arrow). Axial non-enhanced CT scan (b) obtained at the level of the left brachiocephalic vein shows a low-attenuation (-95 HU) nodule in the trachea.

**Fig. 17:** Chest X-Ray in the postero-anterior view (a) and lateral view (b) shows the signs of hyperinflation of the lungs (flattening of hemidiaphragms, widening of retrosternal and retrocardiac spaces - green and yellow stars respectively) and loss of regular vascular branching pattern.

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Fig. 18: Coronal CT reformation at lung window setting (a) with blue-coloured representation of emphysematous areas, prevalent in the upper lobes. 3D image (b) shows the automated lobar segmentation of both lungs for quantification of the lobar emphysema.

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Fig. 19: Chest X-Ray postero-anterior view (a) shows thickening of the bronchial walls and "tramlines" images in the middle and lower regions of the lungs, suggestive of bronchiectasis, confirmed on CT axial images at lung window setting (b,c).

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BRONCHIECTASIS in a 85-yr old man

**Fig. 20:** Axial CT image at lung window setting (a) demonstrates cylindrical bronchiectasis with the typical "signet-ring" sign (arrows): the ring of soft-tissue attenuation represents the thick wall of the dilated bronchus, whereas the circle of soft-tissue attenuation abutting the ring represents a cross-sectional image of the pulmonary artery that lies adjacent to the dilated bronchus. Coronal CT reformation at lung window setting (b) more accurately depicts the presence of patchy areas of decreased lung attenuation in the middle and lower regions of both lungs, due to air trapping.

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Fig. 21: Axial non-enhanced CT image at lung window setting (a) shows diffuse and bilateral centrilobular nodules with tree-in-bud opacities, more accurately depicted by MIP reformation at lung window setting (b).

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Conclusions

The awareness of airway diseases in the elderly is helpful in the management of these diseases, often overlooked and untreated.

- Upper airway disease in the elderly consists of a wide heterogeneous group of disorders, either neoplastic or nonneoplastic. In nonneoplastic disorders, firstly it is important to distinguish between focal and diffuse forms, then presence of calcifications, type of wall thickening and sparing of the posterior wall may be helpful in differential diagnosis.
- Lower airway disease is mainly represented by COPD, bronchiectasis, asthma and bronchiolitis.

MDCT, with 2D and 3D reconstructions is an accurate non-invasive diagnostic tool for diagnosis, staging, pre-treatment evaluation and follow-up.

REFERENCES


