Tracheobronchial lesions - A pictorial review

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Objectives

The tracheobronchial tree can be reviewed on every CT of the thorax. It is not uncommon to see abnormalities of the trachea or lesions within the bronchi.

We present a series of 20 cross sectional images illustrating a variety of these causes and demonstrating salient points relevant to general radiological practice.
Body

Introduction

CT of the thorax is a commonly performed investigation in almost every radiology department. Clinical symptoms of partial airway obstruction are often late and nonspecific therefore imaging provides a vital role in early detection and diagnosis. Multidetector scanners allow multiplanar reconstruction of images which can be of great help when assessing the craniocaudal extent of disease and planning any bronchoscopic or surgical therapy.

Large airway diseases may be congenital or acquired lesions which can be further subdivided into focal and diffuse disease, benign and neoplastic.

Congenital lesions

Tracheal bronchus

Tracheal bronchus is an anomaly of bronchial division arising from the trachea or main bronchus. The anomalous bronchus most commonly arises from the right lateral wall of the trachea (Fig 1) as a result of an extra tracheal outgrowth in embryonic life and has an incidence of 0.1 - 2 % [1]. Patients are usually asymptomatic, but the diagnosis of tracheal bronchus should be considered in cases of recurrent infection, atelectasis or haemoptysis [2]. CT allows visualisation of the entire tracheobronchial tree and can lead to the diagnosis.

Bronchogenic cyst

Bronchogenic cysts are rare [3] and are the result of anomalous development of the ventral foregut. They are usually single but may be multiple and can be filled with fluid or mucus. They can be seen anywhere along the tracheoesophageal course but most are found around the carina [4]. Bronchogenic cysts may discovered antenatally or later either incidentally or following investigation for pain or signs of airway compression. On CT the cysts have well defined borders, which may be smooth or lobulated with water or soft tissue attenuation (Fig 2). They may show calcification in the wall. MR (Fig 3) signal is variable but they do not enhance following gadolinium although enhancement may be seen in the wall [4].
Tracheal atresia/bronchial atresia

In patients with tracheal atresia a segment of the trachea fails to develop. It is fatal unless associated with a tracheo-oesophageal fistula allowing intubation of the oesophagus and subsequent surgical reconstruction of the trachea [2]. Congenital bronchial atresia results from focal obliteration of a segmental or subsegmental bronchus with normal development of the distal airways. Most patients are asymptomatic and it is discovered incidentally in 50% [1]. CT may show a bronchocoele distal to the short atretic segment.

Acquired lesions

Foreign body

Foreign bodies within the tracheobronchial tree are most common in the paediatric age group. Aspirated foreign bodies most commonly are lodged in the right main and lower lobe bronchus. CT is useful in stable patients if the diagnosis is unclear to identify and localize foreign bodies to guide bronchoscopy.

Bronchocoele

A bronchocoele is bronchial dilatation due to retained secretions usually caused by proximal obstruction, which may be congenital or acquired[5]. On CT scans a bronchocoele is seen as a tubular or branching Y or V-shape giving the characteristic finger in glove appearance (Fig 4).

Tracheobronchomalacia

Tracheobronchomalacia is caused by weakness of the tracheobronchial wall and/or supporting cartilage and consequent excessive collapse of the trachea and bronchi [6]. It may be congenital or secondary to trauma, infection, chronic external compression or chronic inflammation. Expiratory CT imaging is required for diagnosis with a 50% expiratory reduction in the cross-sectional luminal area of the airway widely considered diagnostic although recent studies have shown that this may occur in healthy volunteers [6] and a 70% cut off may be more appropriate (Figs 5, 6).
Post intubation stenosis

Post intubation stenosis can occur as a result of endotracheal intubation or tracheostomy tube placement [7]. The site of stenosis is usually at the cuff in the subglottic region in endotracheal cases or at the site of the stoma post tracheostomy [8]. Radiographically the typical features are a soft tissue thickening with luminal stenosis on axial images (Fig 7) and a short hourglass shape narrowing on coronal reconstructions.

Post transplant stenosis

Following lung transplantation anastomotic stenosis occurs in 10 - 15% patients as a result of anastomotic ischaemia [7, 9].

Post-infectious stenosis

Tuberculosis related stenosis has been described in up to 37% of patients with pulmonary TB [7]. Typically strictures involve multiple sites with normal intervening mucosa [10] and may be complicated by external lymph node compression.

Broncholithiasis

A broncholith is a calcified peribronchial node that has eroded into an adjacent bronchus. This is usually secondary to tuberculosis [5]. Symptomatic patients expectorate or aspirate calcified fragments. The CT appearance is a calcified focus within the bronchial lumen (Fig 8) without an associated mass [7].

Retrosternal goitre

Retrosternal goitre (RG) is extension of an enlarged thyroid gland into the thoracic cavity. The retrosternal mass shows CT features and enhancement similar to the cervical component. Rarely the intrathoracic goitre may be a primary RG, i.e. arising from mediastinal thyroid cell rests. Large goitres cause compression of the trachea (Fig 9) and require surgical excision. Preoperative CT evaluation is important to assess the extent and anatomy.

Mucus
Mucus is seen as filling defects within the trachea or bronchi on CT (Fig 10). These are usually easily distinguishable as they have bubbles of air within them or are low density strands. Rarely are they mistaken for other mass lesions, but in those situations, an endoscopy or repeat CT is helpful.

Systemic disease

Some systemic diseases have uncommon airway manifestations which can lead to focal tracheal and bronchial stenoses [11]. These include Crohn’s disease, Sarcoidosis and Behcet Syndrome. In Crohn’s disease inflammation can involve the larynx and subglottic trachea leading to airway narrowing. Up to 3% of patients with sarcoidosis have tracheal involvement due to granuloma formation within the airway or lymph node compression [12]. Vasculitis due to Behcet syndrome can lead to ulceration of the trachea with resultant narrowing.

Bronchopleural fistula

A bronchopleural fistula is a communication between the pleural space and the bronchial tree most commonly seen post pulmonary resection (Fig 11). The diagnosis is suggested if there is an increase in the amount of fluid or air post pneumonectomy with mediastinal shift to the opposite side [13]. Accurate localization of the fistula and size is important for treatment planning.

Tracheal Diverticulum

Tracheal diverticula are uncommon and usually encountered as incidental findings. They are focal out-pouchings from the posterior tracheal wall. The neck of the diverticulum is narrow except in diverticula associated with tracheobronchomegaly. Most of the diverticula arise from the right posterior wall of the trachea as this is the weakest point at insertion of trachealis. The oesophagus appears to give strength to this junction on the left thus protecting this side. There are four classified types. [14] (1) Rudimentary bronchus type - congenital cylindrical out pouching at the right posterior wall, (2) cystic mucus gland type - seen as a small well defined fluid density mass, (3) tracheocele type - a cyst arising from a weakness in the right posterior wall (Fig 12) caused by increased intra-tracheal pressure and (4) tracheal diverticulosis associated with tracheobronchomegaly.

Bronchiectasis
Bronchiectasis is the irreversible dilatation of the bronchi. Childhood infections, tuberculosis, cystic fibrosis and allergic bronchopulmonary aspergillosis can all lead to bronchiectasis. The CT features of bronchiectasis include bronchial dilatation and bronchial wall thickening [11] (Fig 13). The size of the bronchus is compared with the adjacent artery and should be similar in size normally. CT findings have been variously described as 'tram-track', 'signet ring' appearances.

Wegener Granulomatosis

Wegener granulomatosis is an uncommon multisystem necrotizing vasculitis. Airway involvement occurs in 15-25% of patients and is due to mucosal inflammation [15, 16]. The subglottic region is most commonly affected with CT images showing circumferential tracheal wall thickening and luminal narrowing.

Tracheobronchomegaly (Mounier-Kuhn syndrome)

Tracheobronchomegaly is a rare condition characterized by irreversible dilatation of the trachea and proximal bronchi [17]. The cause of this condition is unknown initially thought to be a congenital anomaly but now presumed to be due to chronic irritation and inflammation. [18]. Most cases present from the third decade onwards with chronic cough or repeated respiratory tract infections. CT is the best imaging modality for diagnosis and also demonstrates the scalloped appearances (diverticulosis) (Fig 14).

Relapsing polychondritis

Relapsing polychondritis is characterized by recurrent inflammation of the cartilage of the ear, nose, larynx and tracheobronchial tree [8]. CT demonstrates diffuse or focal airway involvement with tracheal thickening and destruction of cartilaginous rings. The posterior membrane of the trachea is spared with can help distinguish from other diseases.

Tracheobronchopathia osteochondroplastica

Tracheobronchopathia osteochondroplastica is a rare benign disease, which is usually asymptomatic but may cause cough, wheezing and dyspnea on exertion. It is characterized by cartilaginous and osseous sub mucosal nodules projecting into the tracheobronchial tree causing a variable degree of diffuse tracheal
narrowing. CT shows a thickened tracheal cartilage with small (3 to 8 mm) nodules (Fig 15), which may be calcified, protruding into the tracheal lumen [7].

Papillomatosis

Human papilloma virus infection of the upper respiratory tract usually occurs peripartum from an infected mother. Laryngeal papillomas are commonest with distal airways being involved less commonly. Both single and multiple papillomas have been described and the appearance on CT is that of nodular airway narrowing [8, 19].

Calcification secondary to warfarin

Calcification of tracheobronchial cartilage is commonly seen as an age related phenomenon, occurring almost exclusively in patients over the age of 40 years. Calcification has been noted in patients as young as 18 on long term warfarin therapy [20] although the mechanism by which this occurs is thought to be via inhibition of formation of a vitamin-k dependent protein which normally prevents cartilage calcification (Fig 16).

Endobronchial carcinoid

Bronchial carcinoids account for less than 5% of all primary lung tumors in adults and represent 25% of all carcinoids [21]. Typical carcinoids are low-grade tumors neuroendocrine that have an excellent prognosis. They usually present with symptoms of airway obstruction. CT illustrates a well-defined rounded nodule (Fig 17) with a slightly lobulated border. Carcinoid tumours usually show avid contrast enhancement due to their high vascularity.

Carcinoma

Primary neoplasms of the central airways are rare and make up approximately 5% of all lung malignancies [22]. The majority are squamous cell carcinomas. CT demonstrates a polypoid, soft tissue density intraluminal mass (Fig 18) with a smooth or irregular contour [23].

Adenoma
Pedunculated adenomas of the tracheobronchial tree arise from bronchial mucous glands. CT demonstrates a solitary, polypoid mass [23] (Fig 19).

Secondary tracheal malignancy

The central airways may be subject to direct invasion by primary malignancies of the thyroid (Fig 20), oesophagus, lung and larynx. CT will show the primary neoplasm with evidence of an associated cartilage destruction and an endoluminal mass [23].

References


Fig. 1: Right upper lobe bronchus is seen arising from the trachea. In this patient this tracheal bronchus gave rise to the apical and anterior segmental bronchi, while the posterior segmental bronchus of the right upper lobe originated from the right main bronchus.

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Fig. 2: Bronchogenic cyst seen in a 79 year old man seen as a well defined low density (fluid) mass in the subcarinal region, typical location for a bronchogenic cyst. MRI confirmed features of a proteinaceous cyst (Fig.3).

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**Fig. 3:** Same patient as fig:2, T1 weighted images showing well defined high signal rounded mass below the carina. This showed high signal on fat suppressed sequences and intermediate signal on T2 weighted images consistent with a cyst containing proteinaceous material.

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Fig. 4: Bronchocoele on the right seen as a thick branching, finger-like opacity containing inspissated secretion.

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Fig. 5: 40 year old woman treated as asthma for several years with increasing breathlessness. CT showed tracheo-bronchomalacia as the cause of her symptoms, with narrowing of her trachea and main bronchi. Marked narrowing of the antero-posterior diameter of the carina and right and left main bronchi due to collapse of the tracheal and bronchial cartilage.

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Fig. 6: Same patient in Fig. 5 after stenting of her trachea and main bronchi showing a good result.

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**Fig. 7:** Slit-like narrowing of the trachea seen between the lobes of the thyroid in a patient with focal stenosis of the upper trachea following intubation. The trachea is narrowed in antero-posterior and transverse diameters. The rest of the trachea was normal calibre.

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**Fig. 8:** Left upper lobe scarring due to previous TB, bronchiectasis in the apico-posterior segmental bronchus and calcified broncholith within

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Fig. 9: Axial CT image showing marked compression and deviation of the trachea to the right at the thoracic inlet by a large goitre. This goitre extended retrosternally on serial images. CT was done as a pre-operative planning scan for thyroidectomy to relieve compressive symptoms.

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Fig. 10: Coronal reformat showing mucus with air bubbles in the right lower lobe bronchus.

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Fig. 11: 50 year old woman with rheumatoid arthritis who developed a broncho-pleural fistula following surgical excision of a rheumatoid nodule. The right lower lobe bronchus is seen connecting with the pleural space within which is a loculated hydropneumothorax.

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Fig. 12: A loculated tracheal diverticulum (tracheocoele) is seen arising from the upper trachea at its right posterolateral aspect. This is the typical location at the junction of the cartilage with trachealis muscle on the right.

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**Fig. 13:** CT showing cystic bronchiectasis in the right middle lobe, with 'tree-in-bud' appearances in the rest of the lungs.

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Fig. 14: Sagittal reformatted CT image showing marked dilatation of the trachea with sacculations between the cartilage rings consistent with Mounier-Kuhn syndrome. The tracheal calibre measured over 3cm in AP and transverse diameters.

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Fig. 15: A small endoluminal nodule is seen arising from the posterior wall of the trachea. Bronchoscopy demonstrated multiple endotracheal nodules, not all of which were visualized on the CT. Biopsy confirmed tracheopathia osteochondroplastica and both osseous and cartilaginous tissue was present at histology.

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**Fig. 16:** Reformatted coronal CT image showing extensive bilateral bronchial wall calcification in a patient on long term warfarin therapy for atrial fibrillation. This patient also has a large non-small cell carcinoma occupying the left hemithorax.

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**Fig. 17:** Well defined rounded soft tissue mass in the right bronchus intermedius. Biopsy revealed a carcinoid. This mass showed enhancement on the post contrast images.

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Fig. 18: Axial CT showing mass in the upper lobe of the right lung with endoluminal invasion of the right upper lobe bronchus. Bronchoscopic biopsy demonstrated adenocarcinoma of lung origin.

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**Fig. 19:** 46 year old man with haemoptysis. CT shows a well defined rounded mass within the left lower lobe bronchus. Bronchoscopic biopsy confirmed a bronchial adenoma.

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**Fig. 20:** Patient with haemoptysis caused by a slow growing thyroid tumour invading the trachea on the right.
Conclusions

CT provides a noninvasive and accurate way of visualizing tracheobronchial anatomy and pathology. Multiplanar reformats can complement conventional axial CT to demonstrate various disorders and provide essential complimentary information to help plan and guide any necessary bronchoscopic or surgical intervention.