Med. J. Cairo Univ., Vol. 93, No. 2, Accepted 9/3/2025
DOI: 10.22608/MJCU. 671-680, June 2025
www.medicaljournalofcairouniversity.net

Spectrum of Tracheobronchial Lesions Encountered in Multislice CT and Virtual Bronchoscopy: A Review Article

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Abstract

Background: A diverse range of lesions with varying characteristics can damage the major airways. These lesions may cause extrinsic or intrinsic compromise of the airway, some disease may affect the airway in diffuse or focal manner, some cause narrowing of the airway and others presented with abnormal airway widening. A few of these diseases may be subclinical for extended periods of time or diagnosed accidentally, while others might induce airway obstruction symptoms.

Aim of Study: This study aimed to discuss most of the various tracheal & bronchial lesions encountered in multislice computed tomography and virtual bronchoscopy.

Conclusion: Multislice computed tomography and virtual bronchoscopy offer a very reliable & non-invasive technique for the assessment of tracheobronchial lesions.

Key Words: *Tracheo-bronchial lesions – CT – Virtual bronchoscopy.*

Introduction

Normal anatomy:

The normal length of the trachea from the cricoid cartilage to the carina is 10–12cm. As it travels posterior to the manubrial notch, the extra thoracic section of the trachea transitions into the intra-thoracic segment, which is 6–9cm in length **[1].**

During expiration, the trachea is supported by 16–22 C-shaped anterior cartilaginous rings. The tracheal wall consists of a submucosal layer, an inner mucosal layer, muscle and cartilage as well as an adventitial layer. The posterior wall is mostly composed of the thin trachealis muscle, which lacks cartilage support **[2].**

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The coronal diameter of the regular trachea ranges between 13 and 25mm in males and 10 and 21mm in females, whereas the sagittal diameter ranges between 13 and 27mm in males and 10 to 23mm in females **[2,3].**

The right main stem bronchus comes from the tracheal bifurcation as a shorter, more vertically oriented structure with a bigger diameter than the left main stem bronchus. The left and right main stem bronchi are roughly 2.5 and 5cm in length and make 20–30° and 45° angles with the trachea, respectively **[4].**

At end expiration, the trachea decreases in diameter; the degree of tracheal expiratory collapse is widely variable **[5].**

The trachea is supplied by multiple arteries, including the bronchial arteries, the inferior thyroid artery and the intercostal arteries **[3].**

Main text:

I- *Imaging of the trachea and central airways:*

Computed tomography is the preferred modality for assessing the central airways and trachea. As it generates high-resolution pictures which may be

List of Abbreviations:

2D	: Two-dimensional.
3D	: Three-dimensional.
CT	: Computed tomography.
FOB	: Fiber-optic bronchoscopy.
FOV	: Field of view.
kV	: Kilovoltage.
mA	: Milliampere.
MDCT	: Multidetector CT.
VB	: Virtual bronchoscopy.
WL	: Window level.
WW	: Window width.

utilized to create minimum intensity projections, multiplanar reformations, virtual bronchoscopic (VB) images and 3D volume-rendered views [6]. (Figs. 1,2).

CT can clearly delineate the normal morphology and anatomy of the air passages with precision. It is able to precisely assess the adjacent mediastinal structures in terms of mediastinal invasion by malignancies and compression of the airway by surrounding mediastinal masses. CT also provides essential morphologic data on vascular enhancement and tissue features, such as fatty tissue components and calcification of a lesion [7].

Bronchoscopy is still the principal diagnostic method for tracheo-bronchial disorders. A comprehensive radiologic assessment with radiography and CT may reveal particular imaging results (e.g., calcification) that assist in limiting the differential diagnosis and aid in therapeutic or bronchoscopy intervention planning [8].

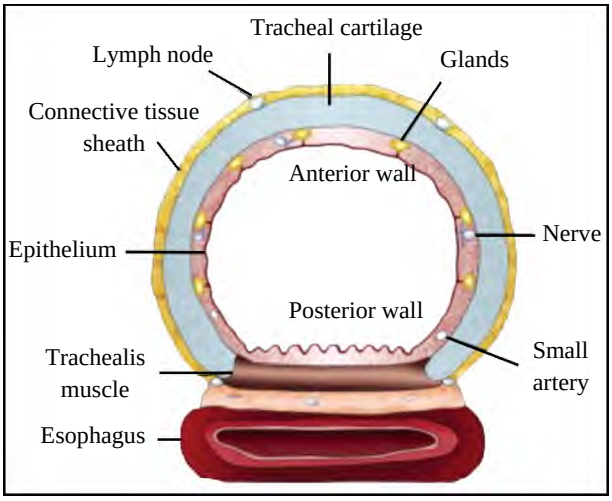


Fig. (1): Tracheal wall anatomy [3].

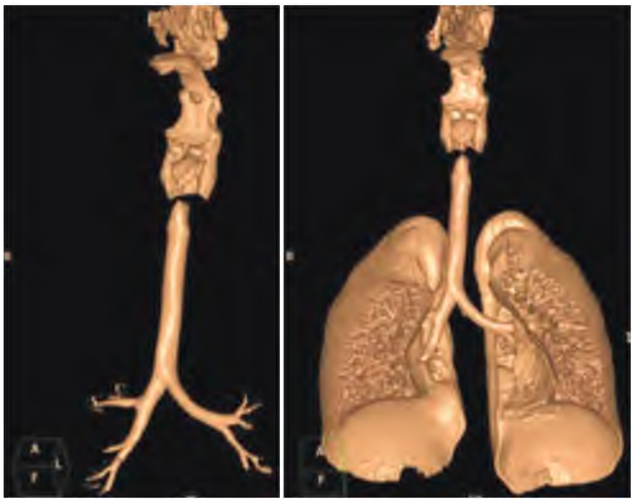


Fig. (2): Normal CT virtual bronchoscopy with 3D volume rendering of the main bronchi and trachea.

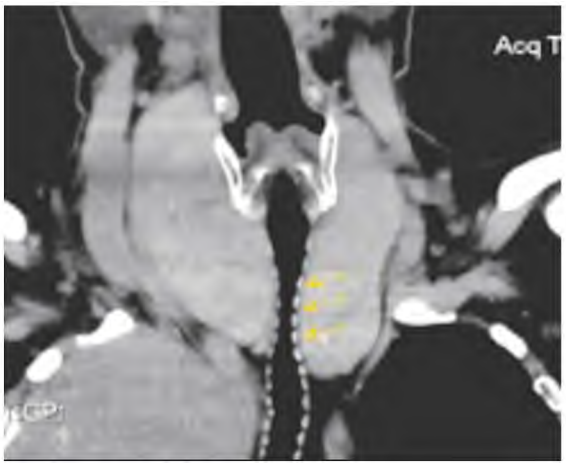
II- *Lesions of the trachea and central airways:*

Imaging of the major airways depicts a wide range of lesions. These lesions can be classified as malignant or benign, intrinsic or extrinsic, localized or diffused, as well as narrowing or dilatation of the airway. Inspecting the lesion's pattern on computed tomography (CT) may help limit the differential diagnosis.

Extrinsic compression:

Enlargement of the adjacent tissues, as the thyroid, esophagus, lymph nodes, thymus, and blood arteries, might compress the major airways. Furthermore, congenital vascular abnormalities can also induce airway compression. On CT, extrinsic compression is shown by luminal constriction. CT can demonstrate luminal narrowing as well as the structure indenting the airway [9]. (Figs. 3,4).

(A)



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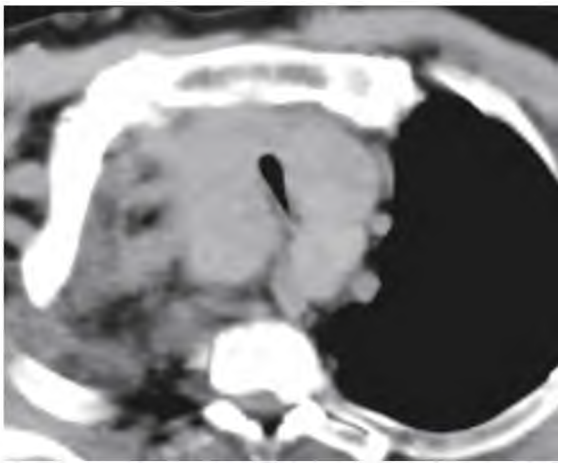

Fig. (3): (A) Coronal (B) Axial CT images of the thoracic inlet showing goiter with retrosternal extension causing marked extrinsic compression and narrowing of the trachea.

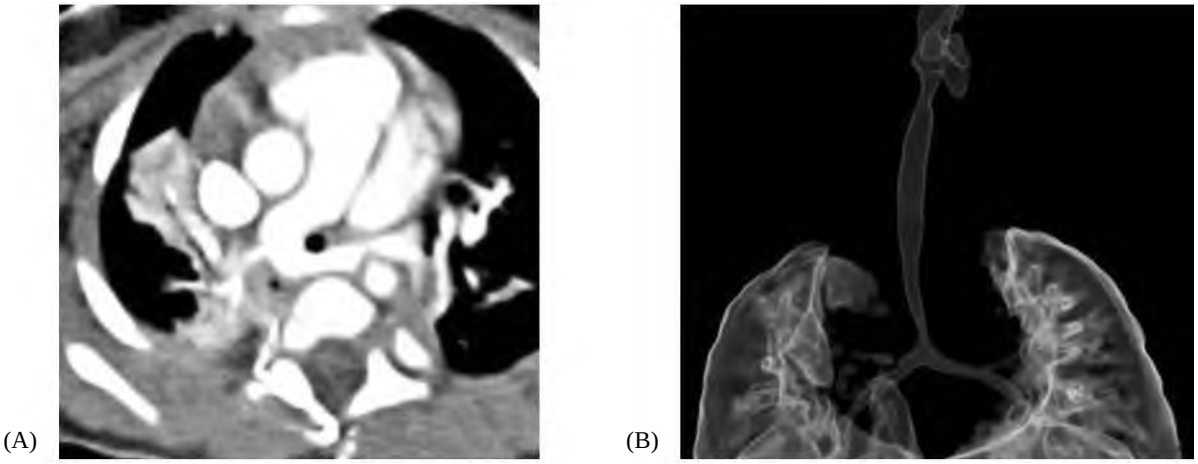

Fig. (4): (A) Axial pulmonary angiography study cut & (B) 3D volume rendering image showing pulmonary artery sling with lower tracheal segment extrinsic compression.

Intrinsic disordersof the central airways may be congenital, post-traumatic, post- inflammatory, neoplastic (Fig. 5) or miscellaneous [9].

Congenital abnormalities:
o Cardiac bronchus.
o Tracheal bronchus.
o Congenital Tracheobronchomegaly "Mounier-Kuhn syndrome".
o Kartagner syndrome.
o Cystic adenomatoid malformation.
o Lung aplasia.
o Bronchial atresia.

Iatrogenic and traumatic abnormalities:
o Post intubation Stenosis.
o Post-operative stenosis.
o Traumatic Injury.

Inflammatory:
o Granulomatosis with Polyangiitis.
o Relapsing Polychondritis.
o Amyloidosis.
o Sarcoidosis.
o Laryngeal scleroma.

Miscellaneous:
o Tracheal diverticulae.
o Endobronchial foreign bodies. Fig. (6).
o Acquired tracheo-bronchomegaly.
o Saber sheath trachea.
o Tracheobronchomalacia.
o Tracheobronchopathia Osteochondroplastica.

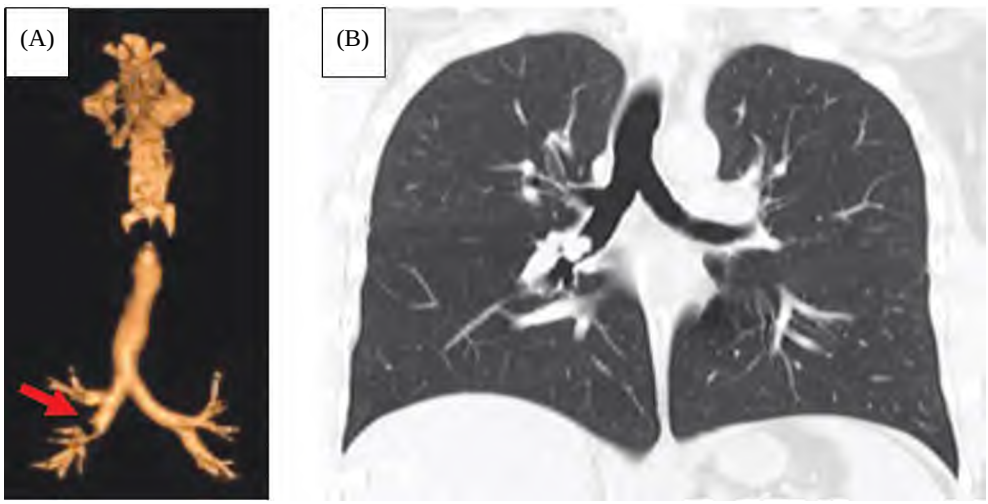

Fig. (5): (A) 3D volume rendering of the tracheo-bronchial tree (B) Coronal CT images of the lungs and tracheobronchial tree showing bronchus intermedius endoluminal polypoid soft tissue mass lesion (arrow) which was pathologically proved to bronchial carcinoid tumor.

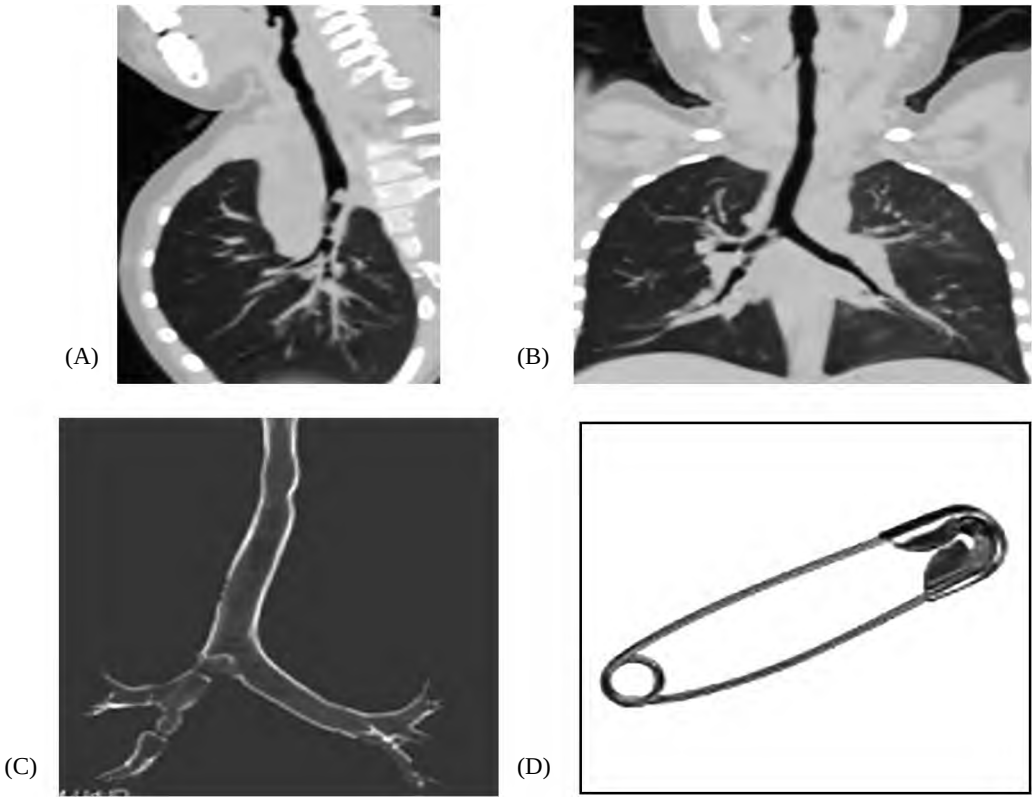

Fig. (6): (A,B) Coronal reconstructed CT images (C) 3D volume rendering of the tracheo-bronchial tree showing right main bronchus endobronchial foreign body (pin).

Tracheal bronchus:

Originally, it was classified as a bronchus of the right upper lobe that arises from the trachea. Recent literature has extended the name "tracheal bronchus" to a number of bronchial abnormalities originating from the trachea or main bronchus and extending to the upper lobe [10].

Accessory cardiac bronchus:

A cardiac bronchus is considered an extra bronchus that arises from the bronchus intermedius or, rarely the right main stem bronchus. This bronchus advances inferiorly and conically toward the pericardium. Some cardiac bronchi divide into bronchioles which terminate in rudimentary bronchiolar parenchyma or an aerated lobulus, but mostly they terminate blindly [11]. Fig. (7).

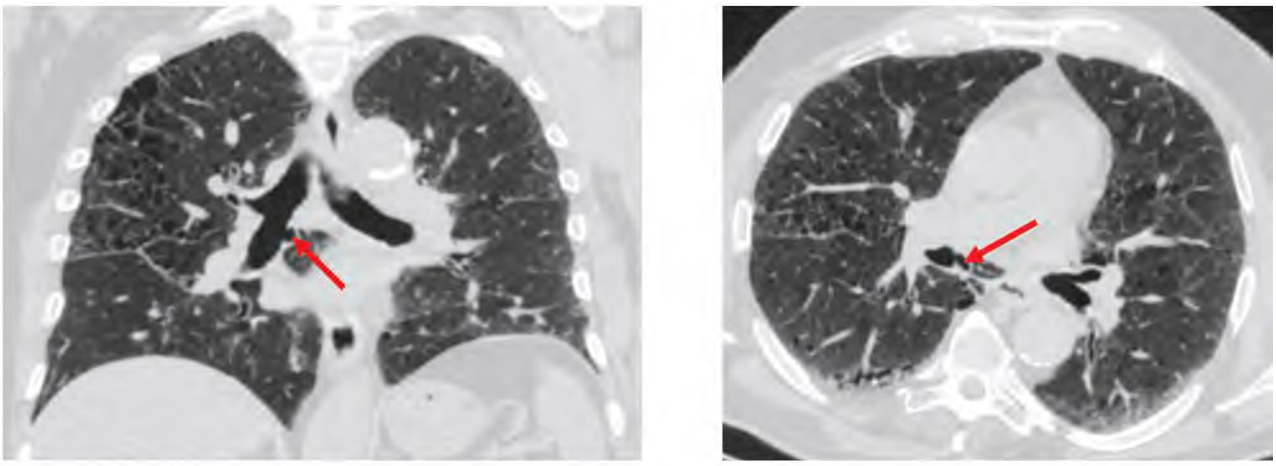

Fig. (7): (A) Coronal (B) Axial CT images of the lung showing accessory cardiac bronchus (arrows).

Congenital tracheobronchomegaly / mounier-kuhn syndrome:

The Mounier-Kuhn syndrome is a congenital condition characterised by a lack of smooth muscle and elastic tissue. It is frequently diagnosed between the ages of 30 and 40 with male predilection and is associated with recurrent respiratory infections. There is extensive dilatation of the trachea, main, and lobar bronchi, followed by an abrupt transition at thesegmental level to bronchi with a normal appearance. Mucosa often protrudes between the cartilage rings through the trachealis muscle [12]. CT may also reveal a corrugated airway wall, many tiny diverticulae, and central bronchiectasis, in addition to an enlarged tracheal diameter [13].

Post-intubation stenosis:

Tracheal stenosis can be a consequence of either endotracheal intubation or tracheostomy tube installation. Mucosal necrosis may arise from the high pressure of the endotracheal tube balloon against the tracheal wall. Mechanical irritation, infection, positive pressure breathing and the use of steroids may aggravate this damage and result in stenosis and scarring. Stenosis often develops in the subglottic area near the cuff site of endotracheal tubes. The common radiologic result is a symmetric, less than 2 cm long, hourglass-shaped constriction [8]. Fig. (8).

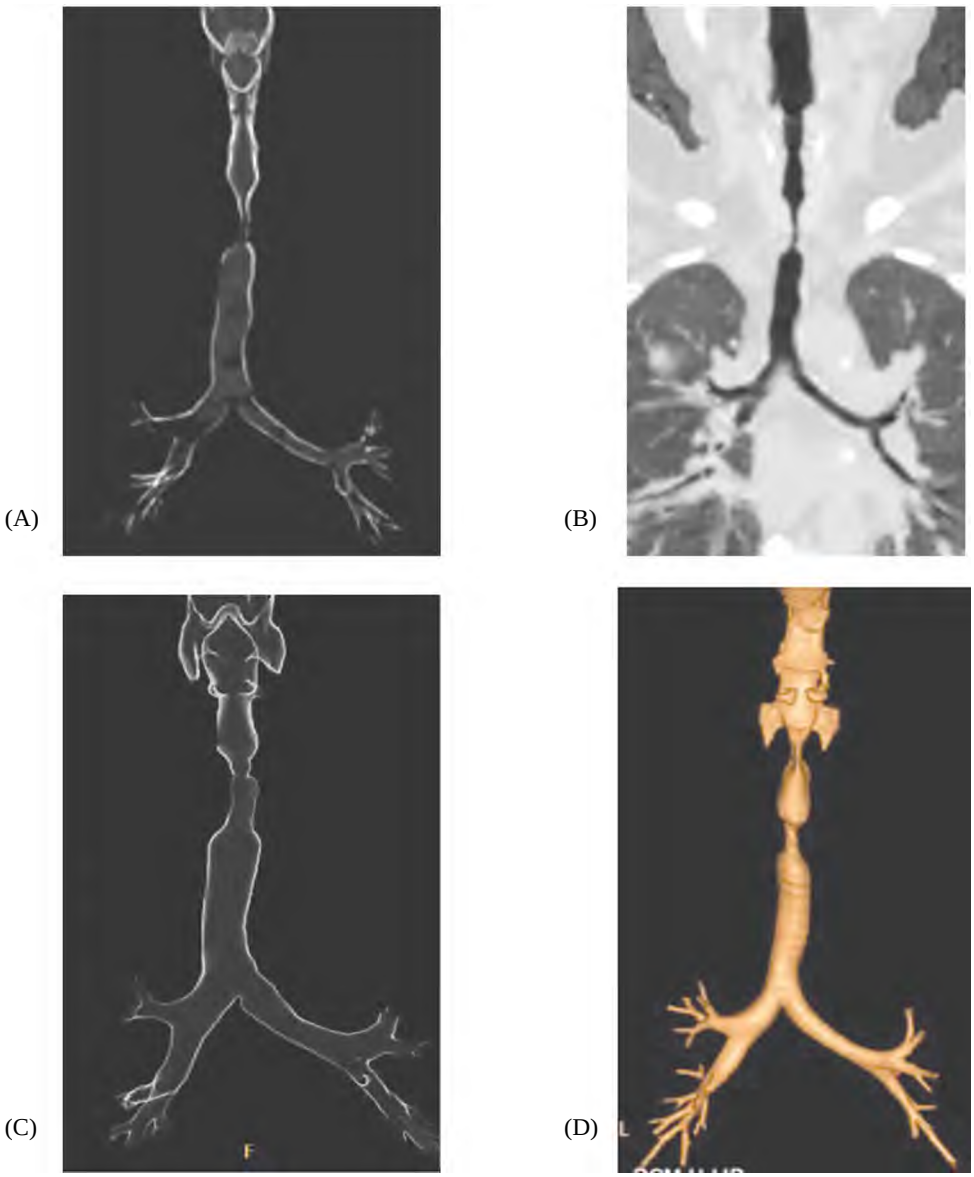

Fig. (8): (A-D) Coronal reconstruction and 3D volume rendering of the tracheo-bronchial tree in different patients with subglottic post intubation stenosis.

Post traumatic stenosis:

Tracheal laceration caused by a blunt injury or penetration may develop stenosis as a late outcome due to the formation of fibrotic tissue and scarring at the damage site [8].

Relapsing polychondritis:

It is a rare autoimmune condition that causes progressive, serial inflammation and cartilage degradation in the ears, nose, upper respiratory system, and joints. Fibrosis and granulomatous tissue replace the injured cartilage. Only cartilage and perichondrium are involved. 50% or more of patients may exhibit airway involvement. CT examination may reveal smooth, widespread affection of the trachea and its major branches, sparing the posterior wall which is devoid of cartilage. The wall of the affected airway may exhibit calcification [12]. Fig. (9).

Granulomatosis with polyangiitis:

Granulomatosis with polyangiitis (GPA) is an antineutrophil cytoplasmic antibody–associated vasculitis marked by vasculitis and necrotizing granulomas; GPA typically affects medium-sized and small blood vessels [14]. About 50% of individuals having GPA show involvement of the tracheobronchial tree, which is seldom the only presentation of the condition. On CT there is usually single stenosis or several stenoses caused by either smooth or nodular circumferential thickening of the tracheobronchial wall [15]. Fig. (10).

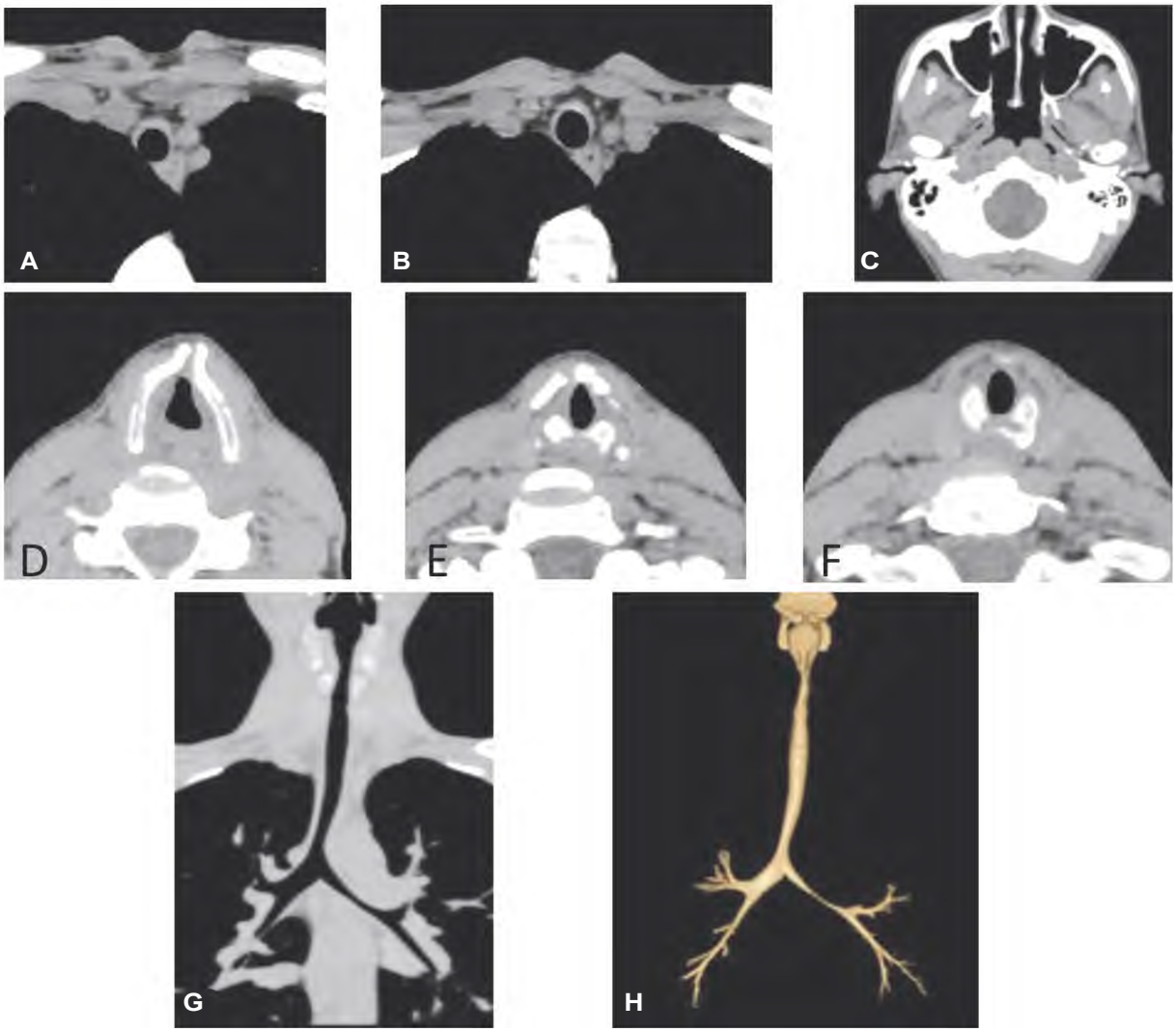

Fig. (9): Diffuse tracheal and left main bronchus stenosis in a patient with relapsing polychondritis. (A, B) axial CT images of the trachea (C) axial CT images of the external auditory canal (D-F) axial CT images of the larynx (G, H) coronal reconstruction and 3D volume rendering of the tracheo-bronchial tree. Images demonstrate diffuse thickening of the cartilaginous portions of the trachea (anterior and lateral walls) sparing the posterior membranous wall with tiny foci of calcification within, irregular ossification and deformity of the laryngeal cartilages as well as mural thickening and calcification of the laryngeal portion of external auditory canals and Eustachian tubes.

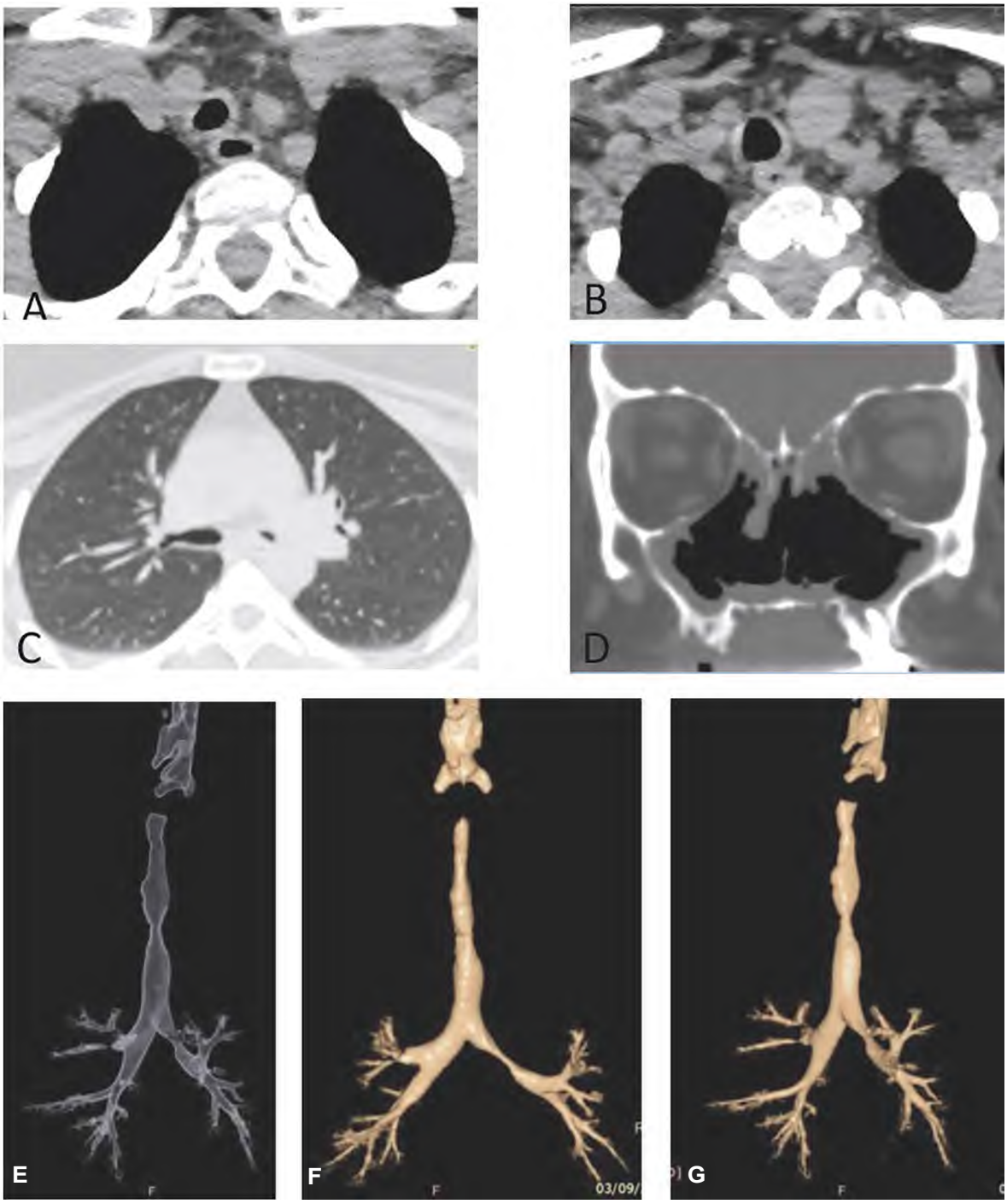

Fig. (10): A case of granulomatosis with polyangiitis (A, B) axial CT images of the trachea (B) axial CT image of the lung at the level of main bronchi (D) coronal CT of the paranasal sinuses (E-G) 3D volume rendering of the tracheo-bronchial tree. Images demonstrate tracheal involvement in the form of circumferential mural thickening and stenosis extending from the subglottic airway to the proximal intra-thoracic trachea with another short stenotic segment involving the left main bronchus. Coronal images of the paranasal sinuses show destructive changes of the nasal septum, nasal turbinates and medial walls of both maxillary antra.

Amyloidosis:

It is an uncommon condition characterized by the extracellular deposition of insoluble proteinaceous fibrils that alters the natural architecture of the airway by causing diffuse or focal airway wall thickening or the formation of masses and nodules that usually grow gradually over time and can lead to airway obstruction. The deposits may exhibit calcification and contrast uptake. Associated calcified hilar and mediastinal lymphadenopathy is possible *[12]*.

The CT scan shows rather diffuse nodular thickening of the trachea and major bronchi, which fre-

quently involves the subglottic trachea. Lobar or segmental atelectasis may be caused by bronchial stenosis or occlusion [8]. Commonly, the trachea has calcified nodules, as those seen in tracheobronchopathia osteochondroplastica. Airway affection is often circumferential in Amyloidosis, whereas in tracheobronchopathia osteochondroplastica and relapsing polychondritis there is sparing of the posterior tracheal and bronchial walls. In addition amyloidosis may affect the larynx and pharynx [16].

Sarcoidosis:

It is a multisystem non-caseating granulomatous disease of unknown etiology that affects the thoracic lymph nodes and lungs [17]. Nevertheless, some individuals will experience tracheal involvement, mainly in the upper trachea. Extrinsic compression from larger lymph nodes or granuloma development inside the airway mucosa and submucosa may contribute to airway constriction [18]. Early airway anomalies are characterised by irregular, smooth or nodular luminal constriction. In the latter stages, fibrotic parenchymal alterations twist the airways and create traction bronchiectasis [17].

Tracheobronchopathia osteochondroplastica:

Numerous rigid osteocartilaginous nodules grow in the submucosa of the anterior and lateral walls of the trachea and major bronchi, sparing the posterior membranous wall. It often affects men over the age of 50 [12]. On (CT), 1–3mm nodules develop from cartilage rings and expand into the lumen of the airway; the location of these nodules is sometimes better represented using virtual bronchoscopy. Similar to relapsing polychondritis, the posterior tracheal and bronchial walls are not affected. However, localized coarse calcification and ossification are more indicative of tracheobronchopathia osteochondroplastica [19].

Saber-sheath trachea:

Almost mainly affecting men with chronic obstructive pulmonary disease, saber-sheath trachea is a frequent tracheal malformation [2]. The extra-thoracic trachea is spared. However, the intra-thoracic trachea demonstrates a notablereduction in coronal diameter with concomitant rise in sagittal diameter, without thickening of the tracheal wall. This tracheal malformation is considered to develop from repetitive intrathoracic tracheal trauma caused by continuous coughing. Other smoking-related diseases such as emphysema and respiratory bronchiolitis may be present [20].

Tracheomalacia:

It results from weakened tracheobronchial wall and myoelastic element hypotonia. Such condition is characterised by collapse of the intra-thoracic trachea secondary to increased intra-thoracic pressure on expiration, which is exacerbated during forced expiration [2]. Long-term intubation, congenital anomalies, persistent extrinsic compression by vascular ring or sling, chronic inflammation, chronic obstructive pulmonary disease and infection are among the causes of tracheomalacia. Traditionally, it was defined as 50% or more collapse of the trachea on CT during expiration [2]. On axial CT, the tracheal posterior membrane typically curves anteriorly, giving an inverted U-shaped air column known as the “frown” sign [21]. However, current information shows that up to 78% of healthy people may show collapse of the trachea of higher than 50% during dynamic expiration [5].

In a smaller number of people, the trachea may have a crescent form on inspiration, defined as a larger coronal diameter than sagittal diameter. This observation strongly suggests tracheomalacia, which can be confirmed by dynamic expiratory CT [21].

Conclusion:

MDCT is a good tool for detecting and classifying diseases of the central airways. Multiplanar reformatted CT scans give detailed disease pattern information. Additionally, VB provides a three-dimensional view of the lesion that mirrors that obtained by FOB. VB can act as a navigation map during transbronchial aspiration and biopsy of hilar and mediastinal masses, and it is regarded as a valuable instrument for determining the status of the tracheal lumen distally, playing an essential role in preprocedural planning for stent placement.

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طيف آفات القصبة الهوائية التي تمت مواجهتها في التصوير المقطعى متعدد الشرائح وتنظير القصبات الافتراضى : مقالة مراجعة

يشير مصطلح الطرق الهوائية المركزية إلى القصبة الهوائية وفروعها الرئيسية يمكن تصنيف الأمراض التى تؤثر على الشعب الهوائية المركزية وفقاً لمسبباتها إلى الأورام وغير الورمية أو من خلال مظهرها التصويرى.

قد تسبب هذه الآفات ضررًا خارجيًا أو جوهريًا للمجرى الهوائى وقد تؤثر بعض الأمراض على مجرى الهواء بطريقة منتشرة أو بؤرية.

قد يكون عدد قليل من هذه الأمراض تحت الإكلينيكى لفترات طويلة من الزمن أو يتم تشخيصها عن طريق الخطأ قد يكون عدد قليل من هذه الأمراض تحت الإكلينيكى لفترات طويلة من الزمن أو يتم تشخيصها عن طريق الخطأ بينما البعض الآخر قد يسبب أعراض انسداد مجرى الهواء.

التصوير المقطعى هو طريقة التصوير المفضلة لتقييم القصبة الهوائية والممرات الهوائية المركزية. يقوم التصوير المقطعى المحوسب متعدد الكاشفات بإنشاء صور عالية الدقة يمكن استخدامها لإنشاء إسقاطات ذات حد أدنى من الكثافة إصلاحات متعددة المستويات، وصور تنظيرالقصبات الافتراضية وعروض ثلاثية الأبعاد.

لا يزال تنظير القصبات هو الطريقة التشخيصية الرئيسية لاضطرابات القصبة الهوائية قد يكشف التقييم الإشعاعى الشامل باستخدام التصوير الشعاعى والتصوير المقطعى عن نتائج تصوير معينة مثل (التكلس) التى تساعد فى الحد من التشخيص التفريقى والمساعدة فى تخطيط التدخل العلاجى أو تنظير القصبات.