Airway Diseases and Disorders, Large and Small

J. Erik Winterholler, MD
Abdominal Imaging and Intervention Fellow, University of Wisconsin - Madison
Kevin M. McDonald, MD
Assistant Professor, Thoracic & Cardiovascular Imaging, University of Wisconsin - Madison

Department of Radiology
UNIVERSITY OF WISCONSIN
SCHOOL OF MEDICINE AND PUBLIC HEALTH

OBJECTIVES

- Review clinical features and treatment of congenital and acquired pathologies of the large and small airways
- Describe typical imaging findings of describe large and small airway diseases
- Provide relevant case examples of described airway diseases
- Not intended to be in-depth review of each disease, rather an overview with key take-aways and imaging

Department of Radiology
UNIVERSITY OF WISCONSIN
SCHOOL OF MEDICINE AND PUBLIC HEALTH

LARGE AIRWAY DISEASES

- Anatomic variants
  - Tracheal bronchus
  - Bronchial Atresia
  - Tracheomegaly (Mounier-Kuhn)
- Iatrogenic and Acquired
  - Tracheoesophageal fistula
  - Excessive central airway collapse and tracheomalacia
- Inflammatory and Infiltrative Diseases
  - Tracheobronchial amyloidosis
  - Relapsing Polychondritis
  - Allergic bronchopulmonary aspergillosis

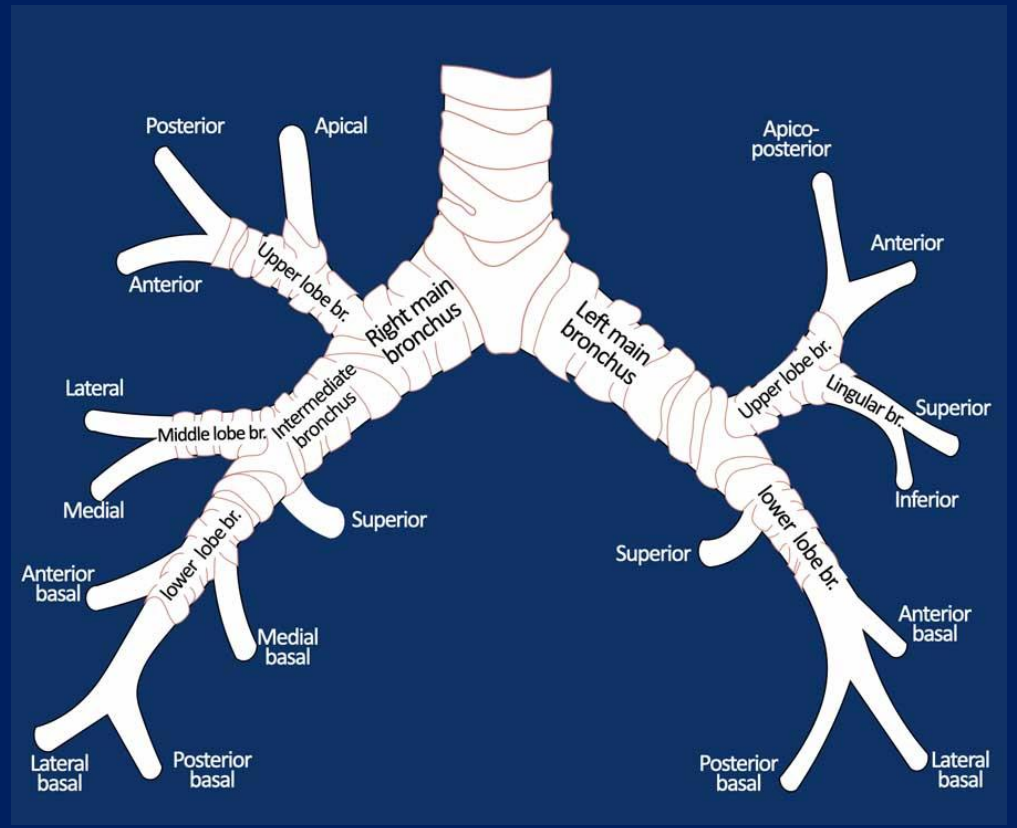
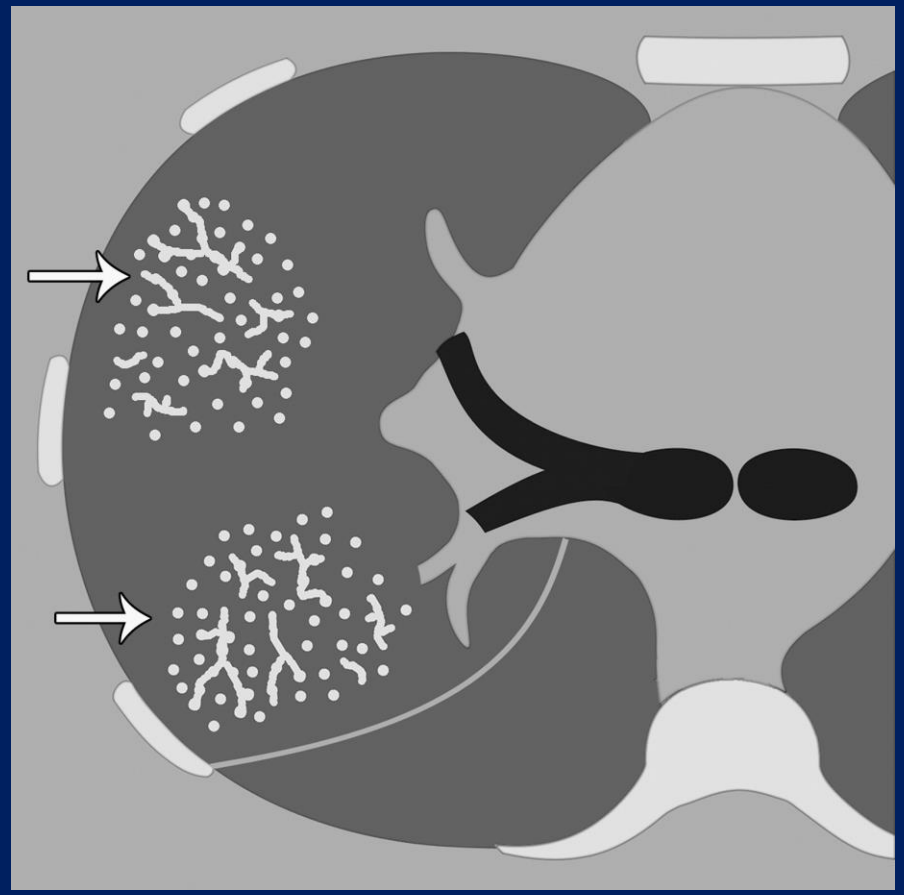


Image courtesy of https://radiologyassistant.nl/chest/lung-anatomy/lung-segments

Department of Radiology
UNIVERSITY OF WISCONSIN
SCHOOL OF MEDICINE AND PUBLIC HEALTH

SMALL AIRWAY DISEASES

- Infectious bronchiolitis
- Aspiration bronchiolitis
- Respiratory bronchiolitis
- Hypersensitivity pneumonitis
- Constrictive bronchiolitis



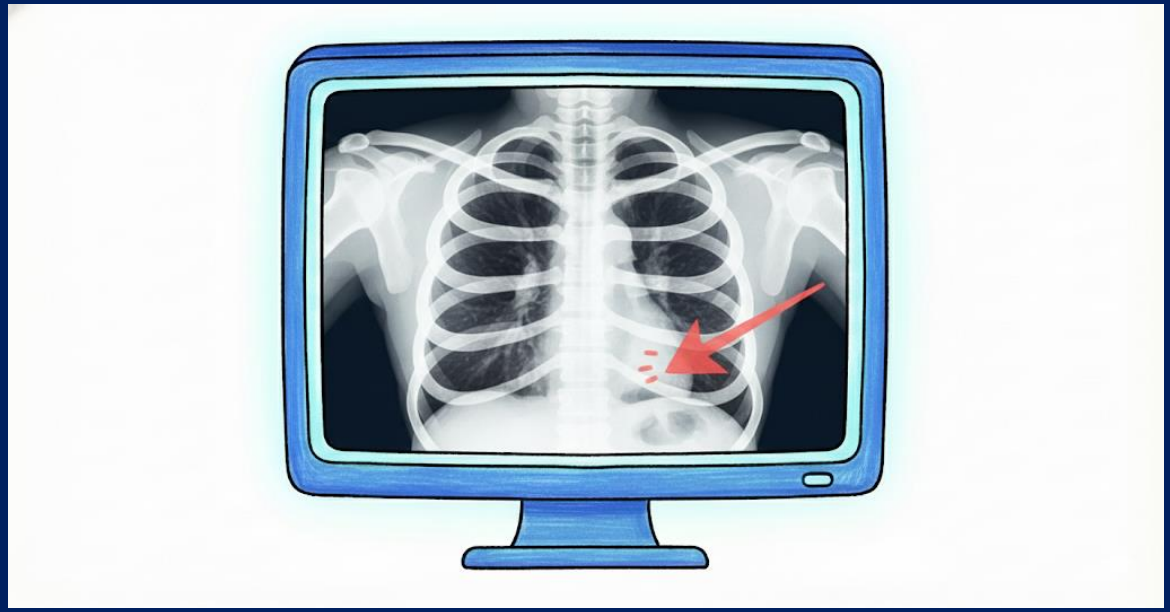
Winningham PJ, Martínez-Jiménez S, Rosado-de-Christenson ML, Betancourt SL, Restrepo CS, Eraso A. Bronchiolitis: A Practical Approach for the General Radiologist. Radiographics. 2017 May-Jun;37(3):777-794. doi: 10.1148/rg.2017160131. Epub 2017 Mar 31. PMID: 28362556.

Department of Radiology
UNIVERSITY OF WISCONSIN
SCHOOL OF MEDICINE AND PUBLIC HEALTH

SLIDE STRUCTURAL OVERVIEW

cp	**Clinical pearls about disease presentation, risk factors, comorbidities, treatment**
	Description of typical imaging findings associated with the condition
	Caption for case example with representative images and descriptors for case markings

Representative Image(s)

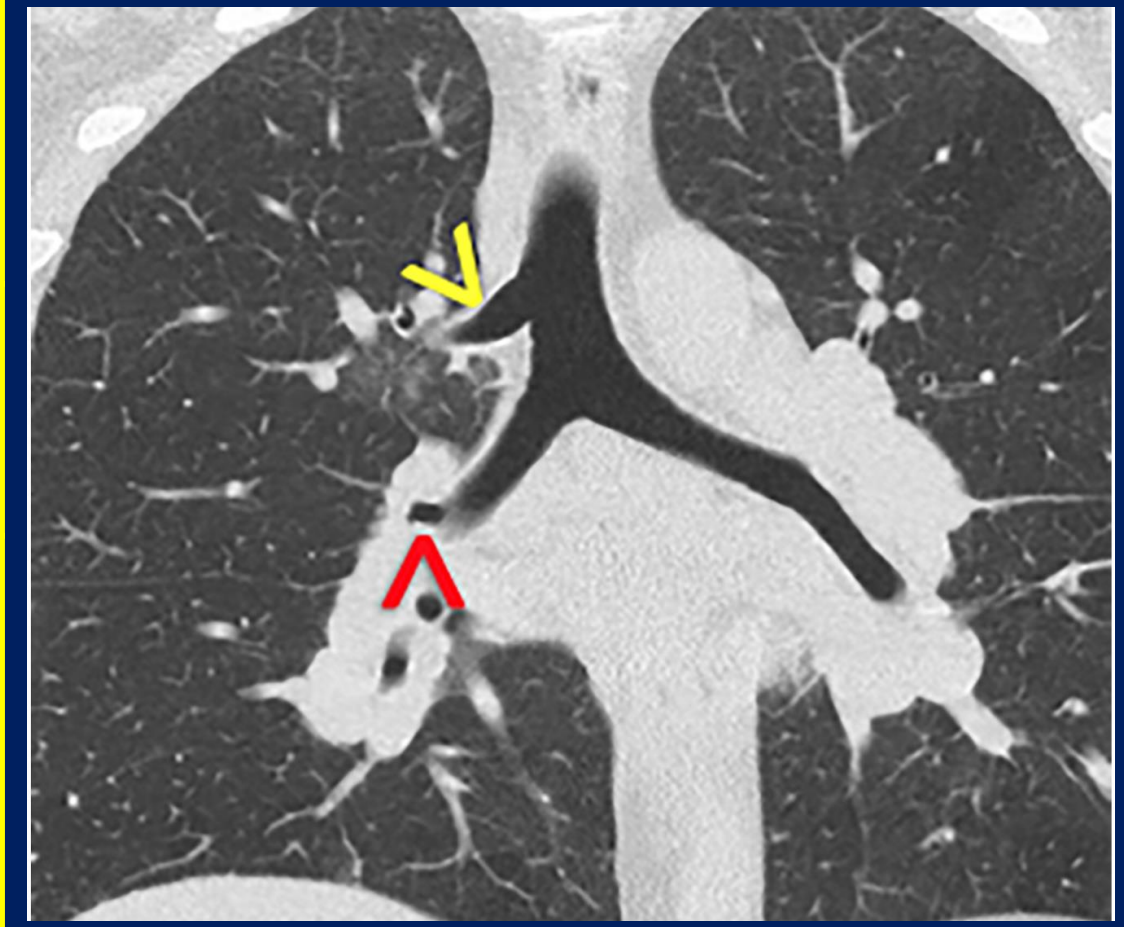


Generated using Gemini Nano Banana

Department of Radiology
UNIVERSITY OF WISCONSIN
SCHOOL OF MEDICINE AND PUBLIC HEALTH

TRACHEAL BRONCHUS – AN ANATOMIC VARIANT

cp	Can be the etiology of hemoptysis, recurrent infections, or chronic cough, though is often asymptomatic.
	Anomalous bronchus arising from the trachea typically within 2 cm of the carina. Most commonly directs air to the right upper lobe.
	Coronal CT with tracheal bronchus (yellow arrowhead) directs air to the apical and anterior segments of the RUL. Small bronchus at expected location of the right main bronchus directs air to the posterior segment (red arrowhead)

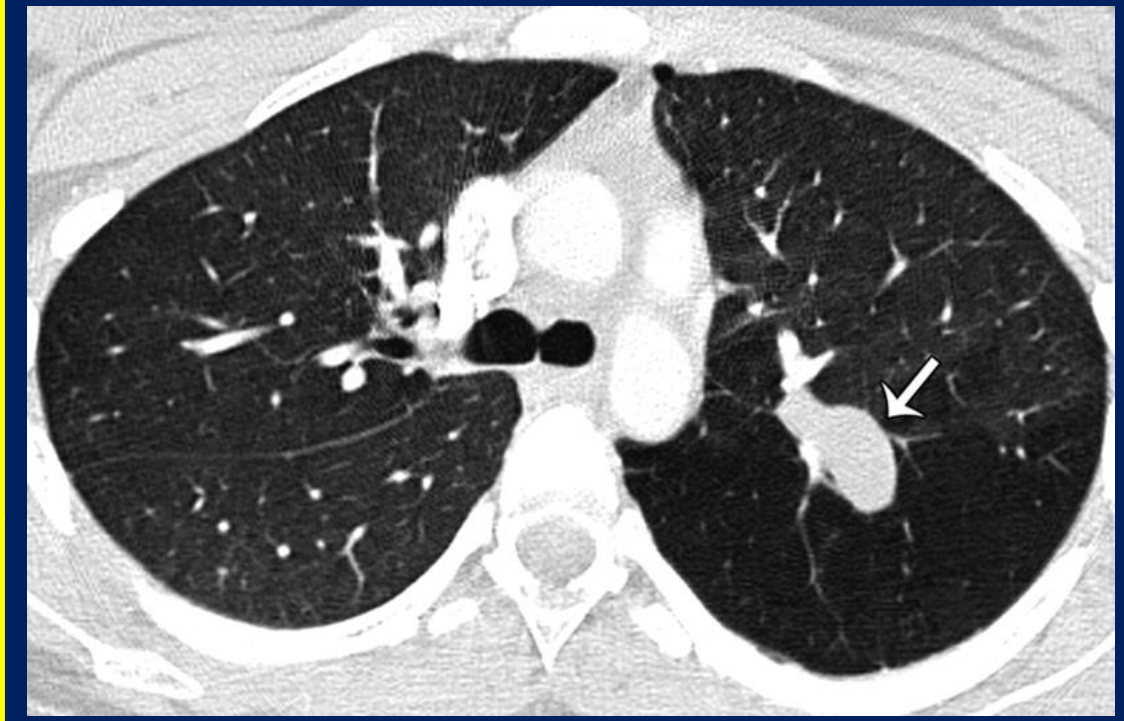


Ko JP. Thoracic Imaging. Clin Chest Med. 2024 Jun;45(2):xvii-xviii. doi: 10.1016/j.ccm.2024.03.001. Epub 2024 Apr 5. PMID: 38816104.

Department of Radiology
UNIVERSITY OF WISCONSIN
SCHOOL OF MEDICINE AND PUBLIC HEALTH

CONGENITAL PATHOLOGY - BRONCHIAL ATRESIA

cp	Most patients are asymptomatic and typically diagnosed in the second and third decades of life. For some, presentation may include chronic cough, recurrent infection, or pneumothorax.
	Tubular branching opacity representing a fluid filled bronchocele that doesn't communicate with the bronchial tree. Hyperlucency of the surrounding lung is related to air trapping.
	Axial CT with bronchocele (arrow) with peripheral air trapping represented by hyperlucent lung. The most common location is the apicoposterior segment of the left upper lobe.



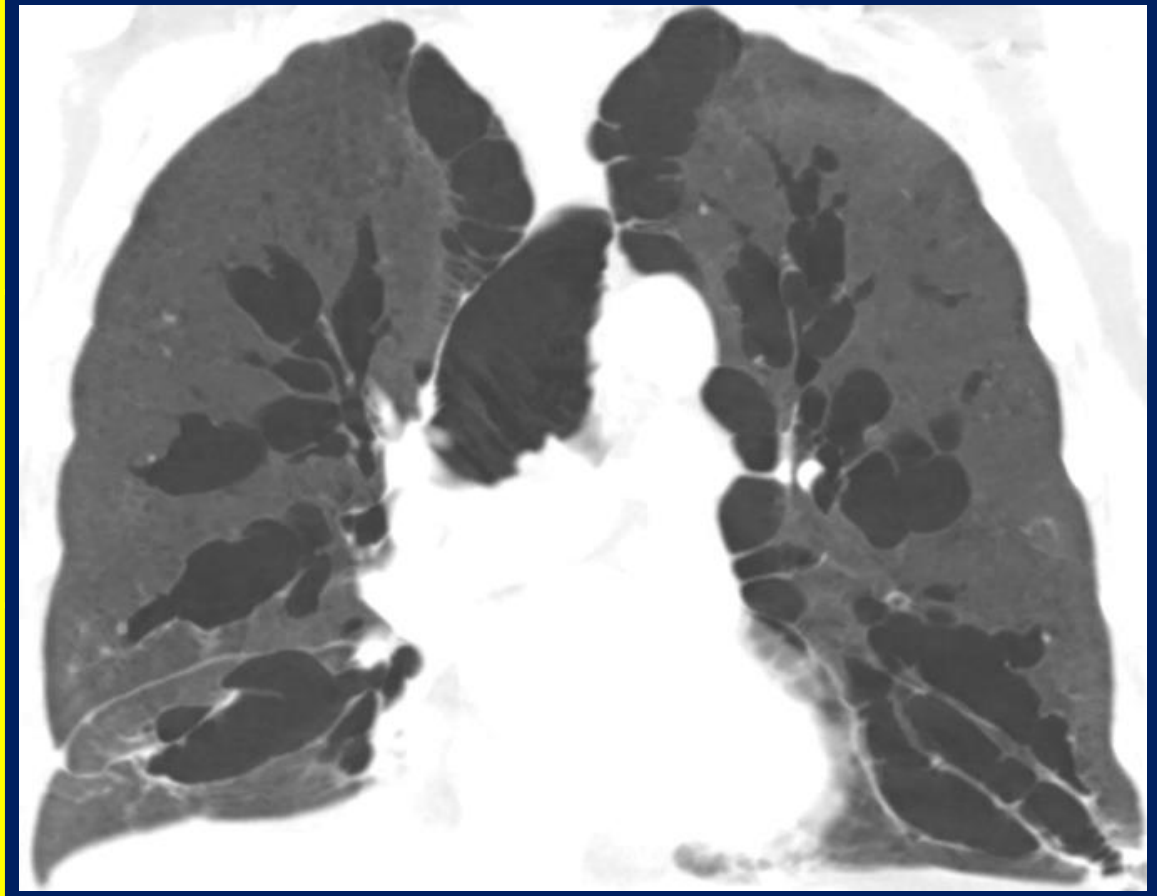
Mestas Nuñez M, Dulcich G, Restrepo CS, Khawaja R, Shankar N, Restauri N, Broncano J, Vargas D. Congenital Lung Anomalies in Adults. Radiographics. 2024 Sep;44(9):e240017. doi: 10.1148/rg.240017. PMID: 39207925.

Gipson MG, Cummings KW, Hurth KM. Bronchial atresia. Radiographics. 2009 Sep-Oct;29(5):1531-5. doi: 10.1148/rg.295085239. PMID: 19755610.

Department of Radiology
UNIVERSITY OF WISCONSIN
SCHOOL OF MEDICINE AND PUBLIC HEALTH

TRACHEOBRONCHOMEGALY (MOUNIER-KUHN SYNDROME)

cp	Manifests in 3rd and 4th decades of life with cough and recurrent infections. Results from atrophy of the elastic and smooth muscle fibers of the tracheal and bronchial walls. Treatment is conservative.
	Markedly corrugated and dilated trachea and central bronchi. Tracheal diameter typically exceeds 3 cm measured 2 cm above the aortic arch.
	Maximum intensity projection (MIP) coronal CT with severely dilated mainstem, segmental, and subsegmental bronchi with mixed cylindrical, varicoid, and cystic appearances.

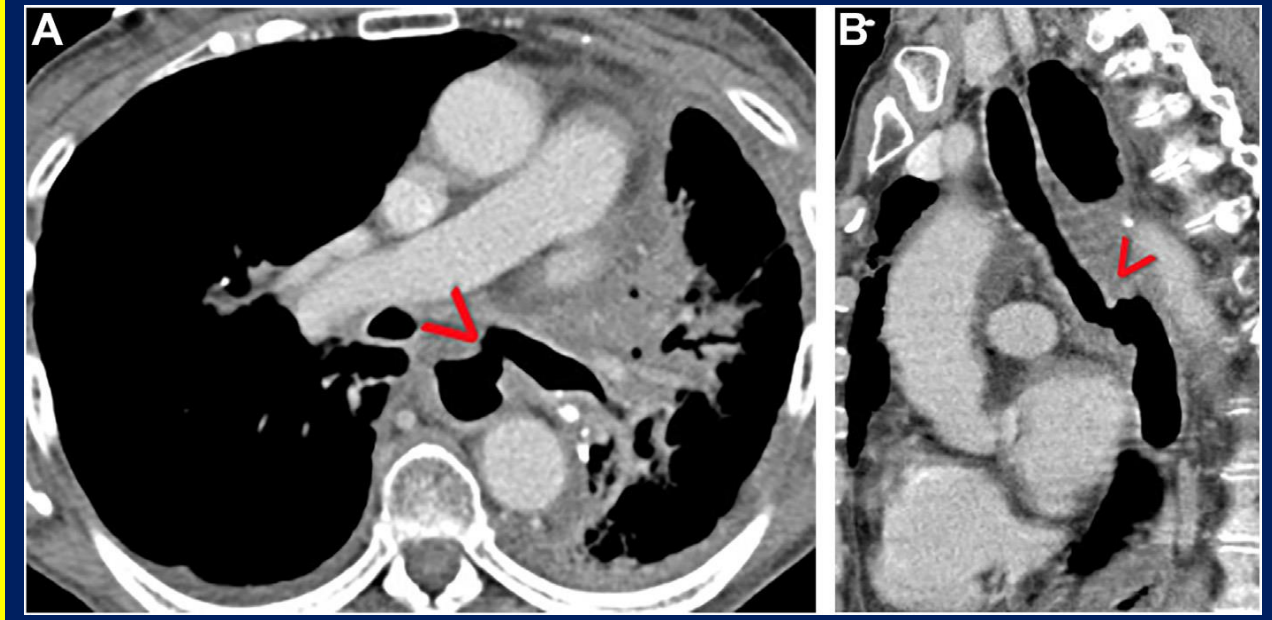


Milliron B, Henry TS, Veeraraghavan S, Little BP. Bronchiectasis: Mechanisms and Imaging Clues of Associated Common and Uncommon Diseases. Radiographics. 2015 Jul-Aug;35(4):1011-30. doi: 10.1148/rg.2015140214. Epub 2015 May 29. PMID: 26024063.

Department of Radiology
UNIVERSITY OF WISCONSIN
SCHOOL OF MEDICINE AND PUBLIC HEALTH

ACQUIRED - TRACHEOESOPHAGEAL FISTULA

	Many acquired causes including malignancy or associated treatment, trauma, and infection. Congenital tracheoesophageal fistula is not discussed here.
	CT esophagram has largely supplanted fluoroscopic esophagram for diagnosis. Any communication between the trachea and esophagus is abnormal. Tracheal thickening, debris, contrast, and pneumomediastinum can all be indicative.
	Axial and sagittal CT with tracheoesophageal fistula as complication of radiotherapy for lung cancer with direct communication (red arrowhead) between the trachea and air-filled esophagus.

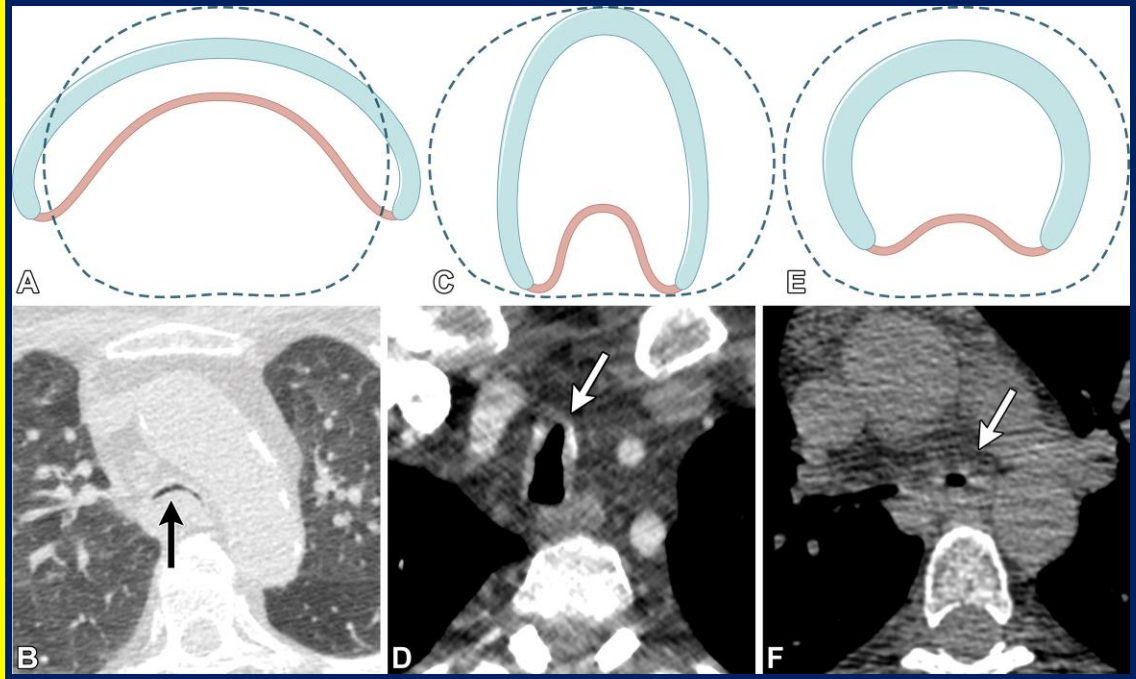


Brixey AG, McCallum R. Imaging of Large Airway Disorders. Clin Chest Med. 2024 Jun;45(2):489-503. doi: 10.1016/j.ccm.2024.02.015. Epub 2024 Mar 27. PMID: 38816102.

Department of Radiology
UNIVERSITY OF WISCONSIN
SCHOOL OF MEDICINE AND PUBLIC HEALTH

EXCESSIVE DYNAMIC AIRWAY COLLAPSE/ TRACHEOMALACIA

cp	Presents with dyspnea, chronic cough, recurrent infections, and difficulty clearing secretions. Can be congenital or acquired related to COPD, asthma, and obesity.
	Tracheomalacia results from weakened tracheal cartilage leading to excessive collapse at expiration. Is differentiated from excessive dynamic airway collapse where only posterior membrane bows excessively, though both entities have significant overlap in imaging features with abnormal airway collapse. Inspiratory/expiratory CT is often needed.
	Three variants of tracheomalacia on expiratory phase axial CT: crescent type (A/B), saber-sheath type (C/D), and circumferential (E/F). Renderings (A,B,C) show normal axial tracheal contour (dotted line) and how these three variants differ.

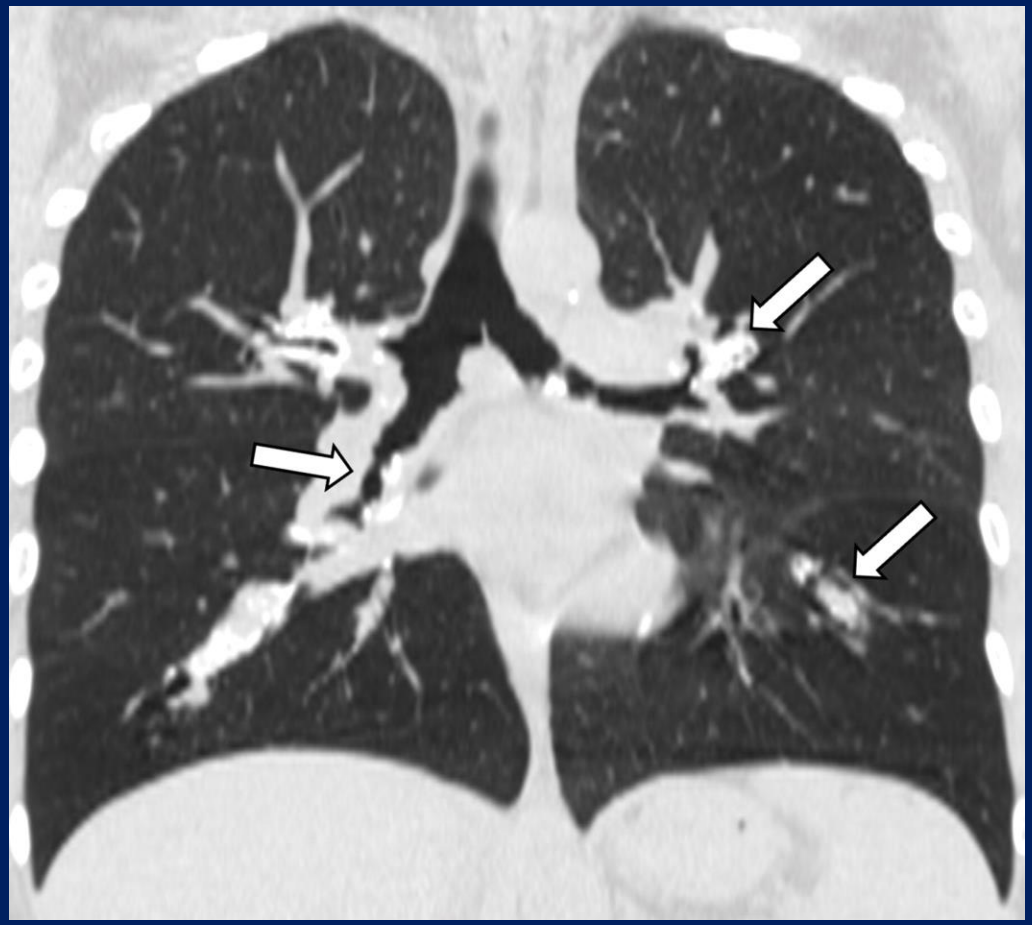


Aslam A, De Luis Cardenas J, Morrison RJ, Lagisetty KH, Litmanovich D, Sella EC, Lee E, Agarwal PP. Tracheobronchomalacia and Excessive Dynamic Airway Collapse: Current Concepts and Future Directions. Radiographics. 2022 Jul-Aug;42(4):1012-1027. doi: 10.1148/rg.210155. Epub 2022 May 6. PMID: 35522576.

Department of Radiology
UNIVERSITY OF WISCONSIN
SCHOOL OF MEDICINE AND PUBLIC HEALTH

TRACHEOBRONCHIAL AMYLOIDOSIS

cp	As with other amyloid depositional diseases, diagnosis requires biopsy and Congo red staining. Treatment is aimed at maintaining airway patency via bronchoscopic interventions, radiotherapy, and chemotherapy.
	Thickened, nodular, and irregular tracheal and bronchial walls that may calcify. Involves the posterior membrane in addition to the cartilaginous trachea. Secondary findings of amyloid deposition elsewhere in the chest may include cardiomegaly and non-specific pleural effusions.
	Coronal CT with tracheal and bronchial thickening with calcified nodules (arrows) with associated airway narrowing.

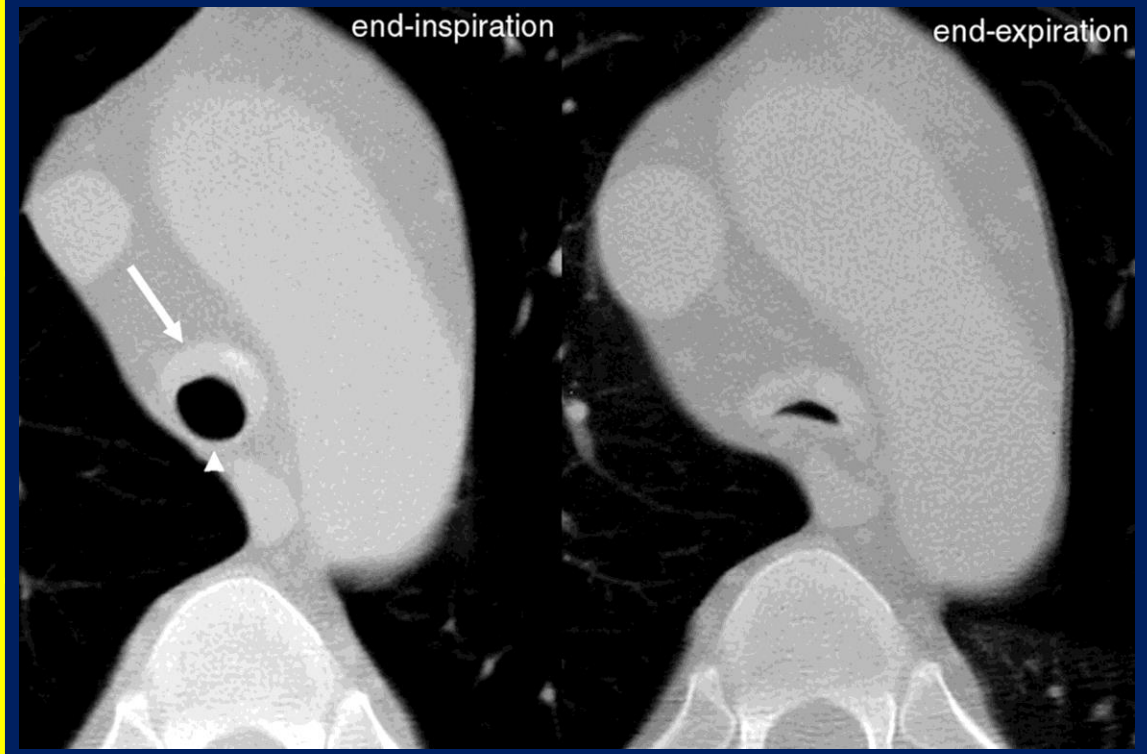


Sugi MD, Kawashima A, Salomao MA, Bhalla S, Venkatesh SK, Pickhardt PJ. Amyloidosis:Multisystem Spectrum of Disease with Pathologic Correlation. Radiographics. 2021 Sep-Oct;41(5):1454-1474. doi: 10.1148/rg.2021210006. Epub 2021 Aug 6. PMID: 34357805.

Department of Radiology
UNIVERSITY OF WISCONSIN
SCHOOL OF MEDICINE AND PUBLIC HEALTH

RELAPSING POLYCHONDRITIS

cp	Dyspnea and stridor, infrequently life-threatening airway collapse, are possible presentations. Mainstay of treatment is glucocorticoids, though refractory disease can be treated with biologic therapy, CPAP, and bronchoscopic intervention.
	Focal or diffuse thickening of the trachea with posterior membrane sparing, which helps to differentiate this entity from other inflammatory and depositional airway disorders. Airway collapse may be seen on expiratory phase.
	Axial CT with thickening of the cartilaginous trachea (arrow) with sparing of the posterior membrane (arrowhead) and airway collapse at end-expiration.

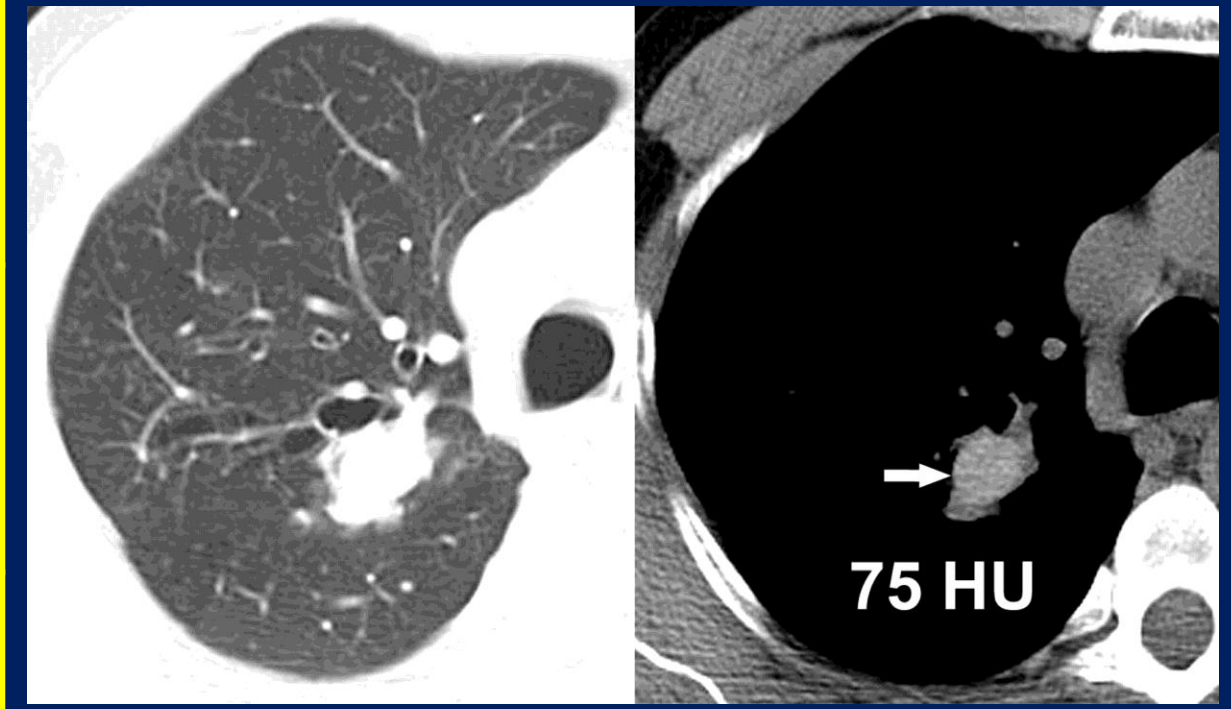


Prince JS, Duhamel DR, Levin DL, Harrell JH, Friedman PJ. Nonneoplastic lesions of the tracheobronchial wall: radiologic findings with bronchoscopic correlation. Radiographics. 2002 Oct;22 Spec No:S215-30. doi: 10.1148/radiographics.22.suppl_1.g02oc02s215. Erratum in: Radiographics.2003 Jan-Feb;23(1):191. PMID: 12376612.

Department of Radiology
UNIVERSITY OF WISCONSIN
SCHOOL OF MEDICINE AND PUBLIC HEALTH

ALLERGIC BRONCHOPULMONARY ASPERGILLOSIS (ABPA)

cp	Typical risk factor is long-standing asthma or cystic fibrosis. Diseases is a result of a hypersensitivity reaction to Aspergillus organisms. Patients present with wheezing, cough, possibly recurrent pneumonias.
	Endobronchial mucoid impaction, which is hyperattenuating in up to a fourth of cases, and bronchiectasis. Other features include consolidation, air trapping, and possible progression to fibrosis.
	Axial CT in lung (left) and soft tissue (right) windows with high attenuation mucous impaction in a dilated bronchus and adjacent bronchiectasis.

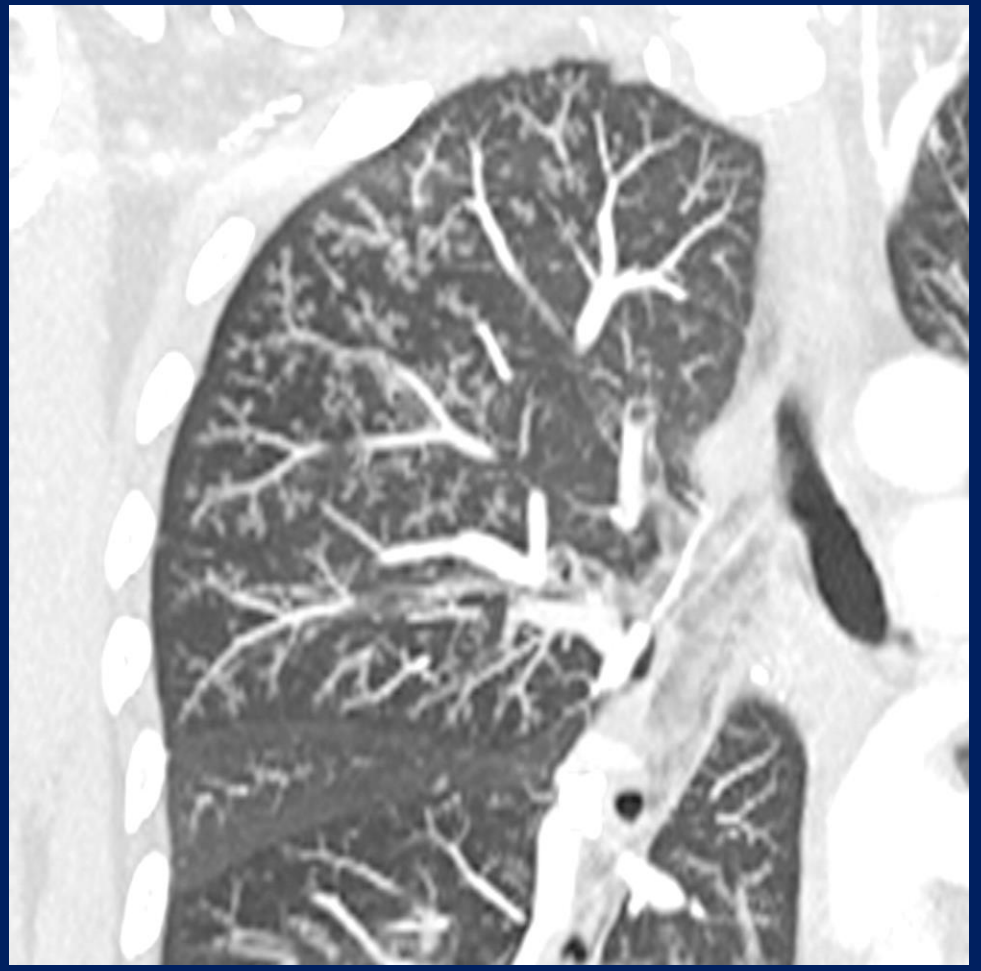


Franquet T, Müller NL, Giménez A, Guembe P, de La Torre J, Bagué S. Spectrum of pulmonary aspergillosis: histologic, clinical, and radiologic findings. Radiographics. 2001 Jul-Aug;21(4):825-37. doi: 10.1148/radiographics.21.4.g01jl03825. PMID: 11452056.

Department of Radiology
UNIVERSITY OF WISCONSIN
SCHOOL OF MEDICINE AND PUBLIC HEALTH

INFECTIOUS BRONCHIOLITIS

cp	Presents with acute onset cough, dyspnea, and constitutional symptoms of infection. If etiology is bacterial, antibiotics are tailored to specific organism. Viral bronchiolitis care is primarily supportive.
	Bacterial/viral: centrilobular and tree-in-bud nodules and ground glass nodules with bronchial wall thickening. Consolidation and atelectasis are more common in children.
	Coronal maximum intensity projection with centrilobular and tree-in-bud nodules in the right upper lobe surrounded by normal aerated lung. NOTE: Centrilobular nodules do not reach the pleural surface.

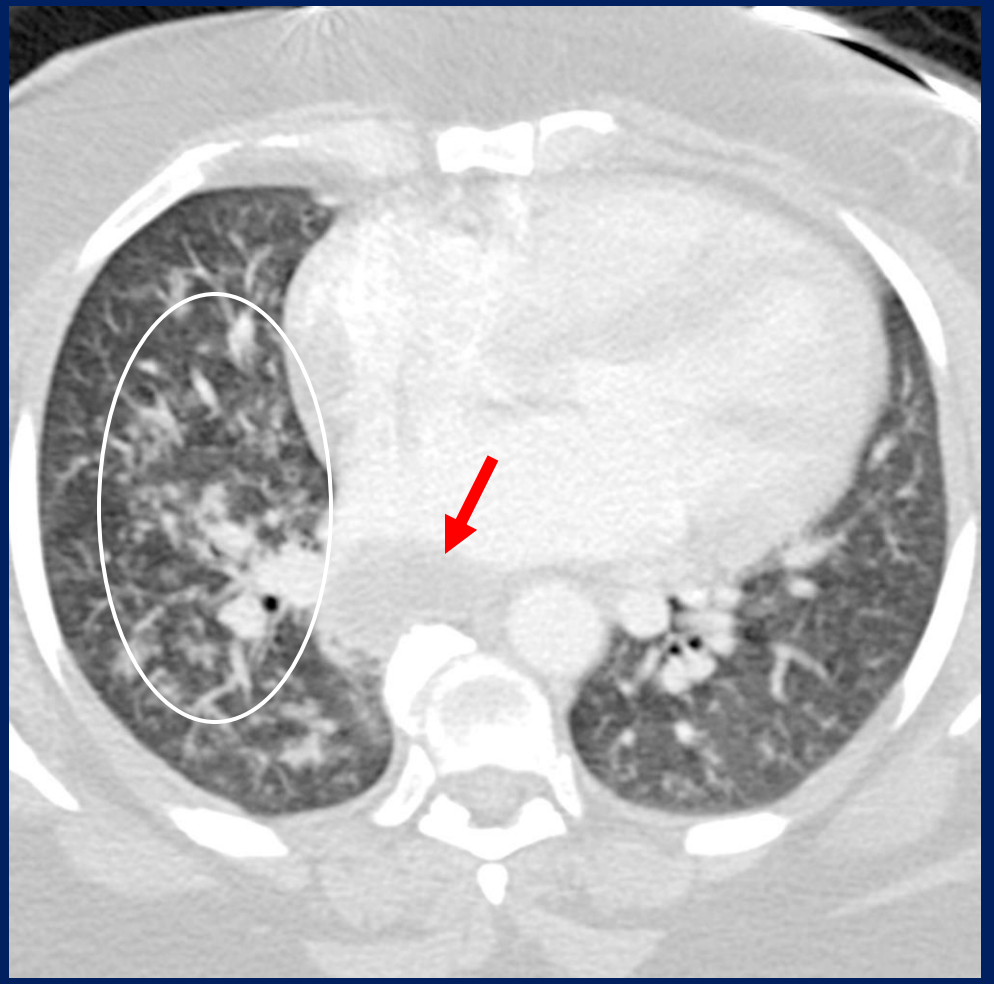


Winningham PJ, Martínez-Jiménez S, Rosado-de-Christenson ML, Betancourt SL, Restrepo CS, Eraso A. Bronchiolitis: A Practical Approach for the General Radiologist. Radiographics. 2017 May-Jun;37(3):777-794. doi: 10.1148/rg.2017160131. Epub 2017 Mar 31. PMID: 28362556.

Department of Radiology
UNIVERSITY OF WISCONSIN
SCHOOL OF MEDICINE AND PUBLIC HEALTH

ASPIRATION BRONCHIOLITIS

cp	Broad risk factor profile from neurologic conditions, esophageal abnormalities, head and neck cancer and its treatment, gastric abnormalities, among others.
	Findings are non-specific so secondary findings or appropriate history/presentation are important to link to aspiration. Typically, patchy lower lobe centrilobular nodules/ground glass +/- consolidation depending on severity and degree of chemical/aspiration pneumonitis.
	Axial CT with a patulous, fluid filled, dilated esophagus (arrow) and right lower lobe centrilobular nodules and ground glass opacities. This patient had a slipped gastric band, predisposing them to reflux/aspiration.

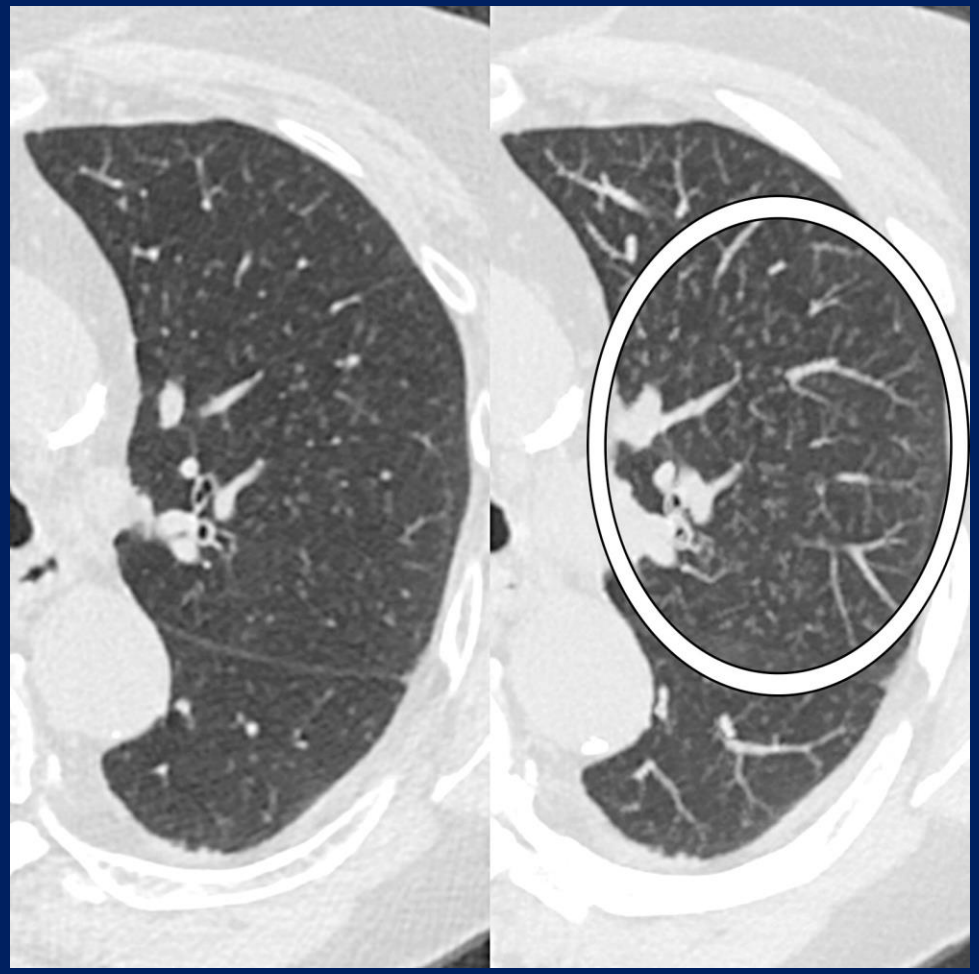


Winningham PJ, Martínez-Jiménez S, Rosado-de-Christenson ML, Betancourt SL, Restrepo CS, Eraso A. Bronchiolitis: A Practical Approach for the General Radiologist. Radiographics. 2017 May-Jun;37(3):777-794. doi: 10.1148/rg.2017160131. Epub 2017 Mar 31. PMID: 28362556.

Department of Radiology
UNIVERSITY OF WISCONSIN
SCHOOL OF MEDICINE AND PUBLIC HEALTH

RESPIRATORY BRONCHIOLITIS

cp	Associated with tobacco smoking and results in submucosal airway inflammation and presence of pigment laden pulmonary macrophages in the airway lumen. May improve with smoking cessation.
	Upper lobe predominant centrilobular ground glass nodules. Can progress to interstitial lung disease, an entity called respiratory bronchiolitis interstitial lung disease (RB-ILD).
	Axial CT (left) and axial maximum intensity projection (right) with left upper lobe centrilobular ground glass nodules in a 63-year-old cigarette smoker.

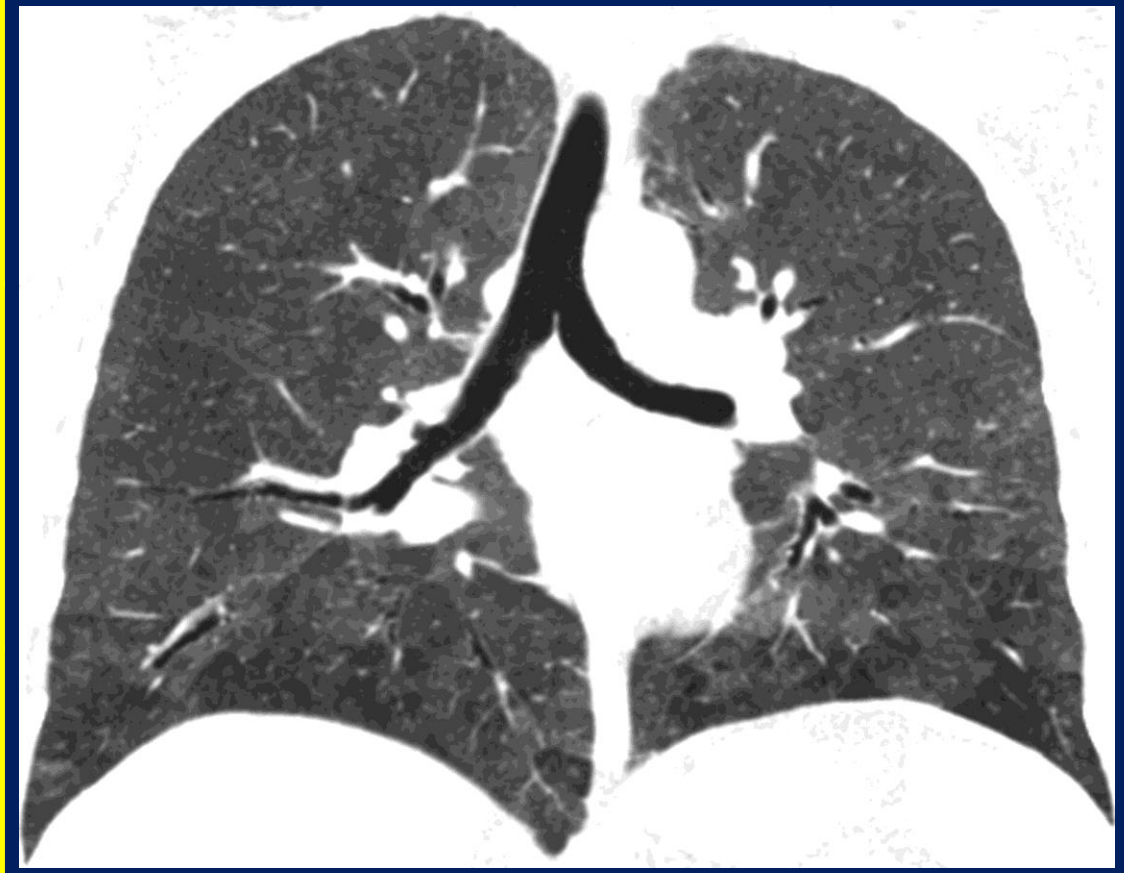


Winningham PJ, Martínez-Jiménez S, Rosado-de-Christenson ML, Betancourt SL, Restrepo CS, Eraso A. Bronchiolitis: A Practical Approach for the General Radiologist. Radiographics. 2017 May-Jun;37(3):777-794. doi: 10.1148/rg.2017160131. Epub 2017 Mar 31. PMID: 28362556.

Department of Radiology
UNIVERSITY OF WISCONSIN
SCHOOL OF MEDICINE AND PUBLIC HEALTH

HYPERSENSITIVITY PNEUMONITIS

cp	Most cases occur after months to years of exposure to the inciting antigen, typically an organic particulate. Presents with dyspnea, cough, and even weight loss in chronic cases.
	Imaging features vary with chronicity, broadly classified into non-fibrotic and fibrotic variants. Upper lobe predominant centrilobular ground glass nodules, air trapping, and the “three density sign” corresponding to lucent lung from to air trapping, normal lung, and ground glass.
	Coronal CT with centrilobular ground glass nodules with an upper lobe predominance and basilar air trapping in this case of non-fibrotic hypersensitivity pneumonitis.

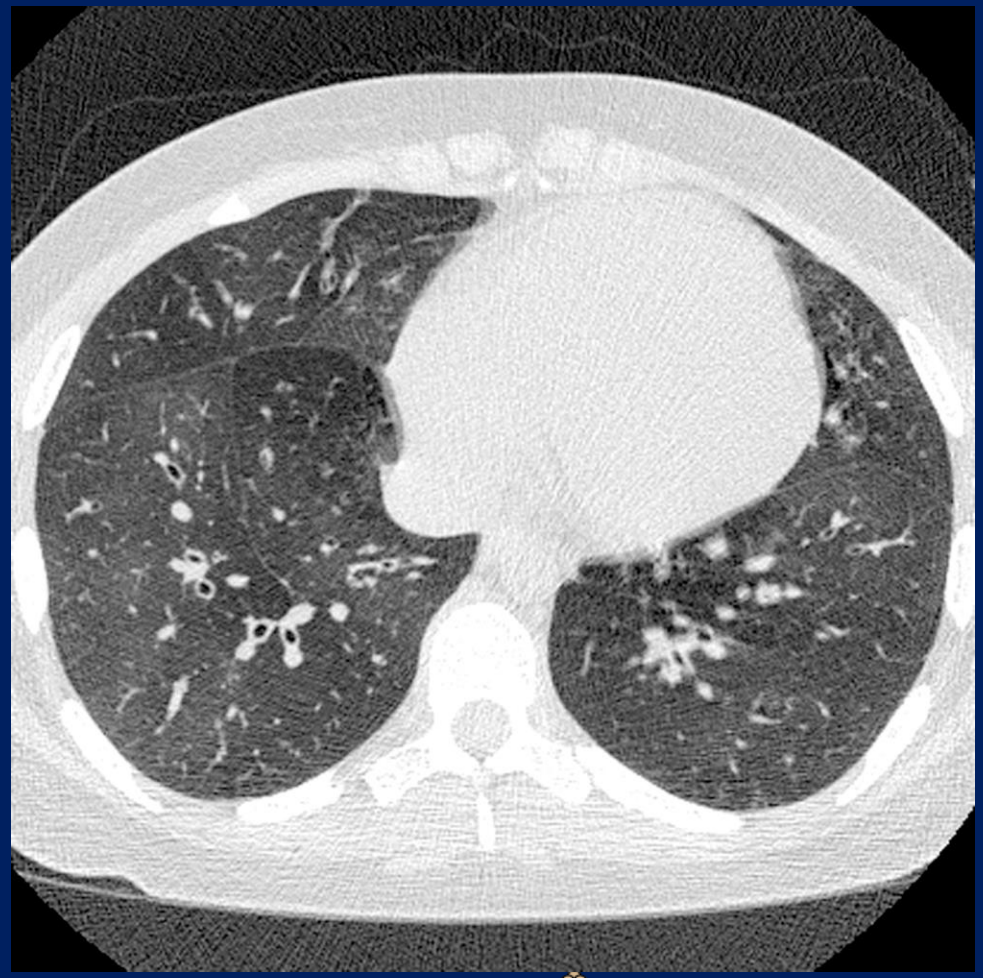


Hirschmann JV, Pipavath SN, Godwin JD. Hypersensitivity pneumonitis: a historical, clinical, and radiologic review. Radiographics. 2009 Nov;29(7):1921-38. doi: 10.1148/rg.297095707. PMID: 19926754.

Department of Radiology
UNIVERSITY OF WISCONSIN
SCHOOL OF MEDICINE AND PUBLIC HEALTH

CONSTRICTIVE BRONCHIOLITIS

cp	Often seen as a delayed complication of lung and bone marrow transplant, usually presenting 6-18 months after transplant. Characterized by abnormal pulmonary function tests, notably an irreversibly decreased forced expiratory volume in 1 second (FEV1).
	Mosaic attenuation, more conspicuous on expiratory phase, is characteristic from patchy air trapping related to bronchiolar narrowing. Can be accompanied by bronchiectasis and bronchial wall thickening.
	Expiratory phase axial CT in this patient with prior bone marrow transplant with bronchial wall thickening and mosaic attenuation related to patchy air trapping.



Winningham PJ, Martínez-Jiménez S, Rosado-de-Christenson ML, Betancourt SL, Restrepo CS, Eraso A. Bronchiolitis: A Practical Approach for the General Radiologist. Radiographics. 2017 May-Jun;37(3):777-794. doi: 10.1148/rg.2017160131. Epub 2017 Mar 31. PMID: 28362556.

Department of Radiology
UNIVERSITY OF WISCONSIN
SCHOOL OF MEDICINE AND PUBLIC HEALTH

RESOURCES

- Ko JP. Thoracic Imaging. Clin Chest Med. 2024 Jun;45(2):xvii-xviii. doi: 10.1016/j.ccm.2024.03.001. Epub 2024 Apr 5. PMID: 38816104.
- Mestas Nuñez M, Dulcich G, Restrepo CS, Khawaja R, Shankar N, Restauri N, Broncano J, Vargas D. Congenital Lung Anomalies in Adults. Radiographics. 2024 Sep;44(9):e240017. doi: 10.1148/rg.240017. PMID: 39207925.
- Gipson MG, Cummings KW, Hurth KM. Bronchial atresia. Radiographics. 2009 Sep-Oct;29(5):1531-5. doi: 10.1148/rg.295085239. PMID: 19755610.
- Milliron B, Henry TS, Veeraraghavan S, Little BP. Bronchiectasis: Mechanisms and Imaging Clues of Associated Common and Uncommon Diseases. Radiographics. 2015 Jul-Aug;35(4):1011-30. doi: 10.1148/rg.2015140214. Epub 2015 May 29. PMID: 26024063.
- Aslam A, De Luis Cardenas J, Morrison RJ, Lagisetty KH, Litmanovich D, Sella EC, Lee E, Agarwal PP. Tracheobronchomalacia and Excessive Dynamic Airway Collapse: Current Concepts and Future Directions. Radiographics. 2022 Jul-Aug;42(4):1012-1027. doi: 10.1148/rg.210155. Epub 2022 May 6. PMID: 35522576.
- Sugi MD, Kawashima A, Salomao MA, Bhalla S, Venkatesh SK, Pickhardt PJ. Amyloidosis:Multisystem Spectrum of Disease with Pathologic Correlation. Radiographics. 2021 Sep-Oct;41(5):1454-1474. doi: 10.1148/rg.2021210006. Epub 2021 Aug 6. PMID: 34357805.

RESOURCES

- Prince JS, Duhamel DR, Levin DL, Harrell JH, Friedman PJ. Nonneoplastic lesions of the tracheobronchial wall: radiologic findings with bronchoscopic correlation. Radiographics. 2002 Oct;22 Spec No:S215-30. doi: 10.1148/radiographics.22.suppl_1.g02oc02s215. Erratum in: Radiographics.2003 Jan-Feb;23(1):191. PMID: 12376612.
- Franquet T, Müller NL, Giménez A, Guembe P, de La Torre J, Bagué S. Spectrum of pulmonary aspergillosis: histologic, clinical, and radiologic findings. Radiographics. 2001 Jul-Aug;21(4):825-37. doi: 10.1148/radiographics.21.4.g01jl03825. PMID: 11452056.
- Winningham PJ, Martínez-Jiménez S, Rosado-de-Christenson ML, Betancourt SL, Restrepo CS, Eraso A. Bronchiolitis: A Practical Approach for the General Radiologist. Radiographics. 2017 May-Jun;37(3):777-794. doi: 10.1148/rg.2017160131. Epub 2017 Mar 31. PMID: 28362556.
- Hirschmann JV, Pipavath SN, Godwin JD. Hypersensitivity pneumonitis: a historical, clinical, and radiologic review. Radiographics. 2009 Nov;29(7):1921-38. doi: 10.1148/rg.297095707. PMID: 19926754.

ADDITIONAL DISEASES FOR FURTHER READING

- Post-intubation tracheal stenosis
- Bacterial tracheitis
- Foreign body aspiration
- Benign and malignant neoplasms of the large airways
- Tuberculosis
- Granulomatosis with polyangiitis
- Tracheobronchopathia osteochondroplastica
- Diffuse idiopathic pulmonary neuroendocrine cell hyperplasia (DIPNECH)

Department of Radiology
UNIVERSITY OF WISCONSIN
SCHOOL OF MEDICINE AND PUBLIC HEALTH