

ACR Appropriateness Criteria®

Tracheobronchial Disease

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Abstract

A variety of thoracic imaging modalities and techniques have been used to evaluate diseases of the trachea and central bronchi. This document evaluates evidence for the use of thoracic imaging in the evaluation of tracheobronchial disease, including clinically suspected tracheal or bronchial stenosis, tracheomalacia or bronchomalacia, and bronchiectasis. Appropriateness guidelines for initial imaging evaluation of tracheobronchial disease and for pretreatment planning or posttreatment evaluation are included.

The American College of Radiology Appropriateness Criteria are evidence-based guidelines for specific clinical conditions that are reviewed annually by a multidisciplinary expert panel. The guideline development and revision process support the systematic analysis of the medical literature from peer reviewed journals. Established methodology principles such as Grading of Recommendations Assessment, Development, and Evaluation or GRADE are adapted to evaluate the evidence. The RAND/UCLA Appropriateness Method User Manual provides the methodology to determine the appropriateness of imaging and treatment procedures for specific clinical scenarios. In those instances where peer reviewed literature is lacking or equivocal, experts may be the primary evidentiary source available to formulate a recommendation.

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Disclaimer: The ACR Committee on Appropriateness Criteria and its expert panels have developed criteria for determining appropriate imaging examinations for diagnosis and treatment of specified medical condition(s). These criteria are intended to guide radiologists, radiation oncologists, and referring physicians in making decisions regarding radiologic imaging and treatment. Generally, the complexity and severity of a patient's clinical condition should dictate the selection of appropriate imaging procedures or treatments. Only those examinations generally used for evaluation of the patient's condition are ranked. Other imaging studies necessary to evaluate other co-existent diseases or other medical consequences of this condition are not considered in this document. The availability of equipment or personnel may influence the selection of appropriate imaging procedures or treatments. Imaging techniques classified as investigational by the FDA have not been considered in developing these criteria; however, study of new equipment and applications should be encouraged. The ultimate decision regarding the appropriateness of any specific radiologic examination or treatment must be made by the referring physician and radiologist in light of all the circumstances presented in an individual examination.

Key Words: Appropriateness Criteria, appropriate use criteria, AUC, bronchial imaging, bronchiectasis, tracheal imaging, tracheal stenosis, tracheobronchomalacia, tracheomalacia

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ACR Appropriateness Criteria[®] Tracheobronchial Disease. [Variants 1 to 6](#) and [Tables 1 and 2](#).

Variant 1. Adult. Clinically suspected tracheal or bronchial stenosis. Initial imaging.

Procedure	Appropriateness Category	Relative Radiation Level
Radiography chest	Usually Appropriate	⦿
CT chest with IV contrast	Usually Appropriate	⦿⦿⦿
CT chest without IV contrast	Usually Appropriate	⦿⦿⦿
CTA chest with IV contrast	May Be Appropriate	⦿⦿⦿
CT neck and chest with IV contrast	May Be Appropriate	⦿⦿⦿⦿
CT neck and chest without IV contrast	May Be Appropriate	⦿⦿⦿⦿
Radiography neck	Usually Not Appropriate	⦿⦿
MRI chest without and with IV contrast	Usually Not Appropriate	○
MRI chest without IV contrast	Usually Not Appropriate	○
CT chest without and with IV contrast	Usually Not Appropriate	⦿⦿⦿
CT neck with IV contrast	Usually Not Appropriate	⦿⦿⦿
CT neck without and with IV contrast	Usually Not Appropriate	⦿⦿⦿
CT neck without IV contrast	Usually Not Appropriate	⦿⦿⦿
CT neck and chest without and with IV contrast	Usually Not Appropriate	⦿⦿⦿⦿
FDG-PET/CT skull base to mid-thigh	Usually Not Appropriate	⦿⦿⦿⦿

Variant 2. Adult. Tracheal or bronchial stenosis. Pre- or posttreatment assessment.

Procedure	Appropriateness Category	Relative Radiation Level
Radiography chest	Usually Appropriate	⦿
CT chest with IV contrast	Usually Appropriate	⦿⦿⦿
CT chest without IV contrast	Usually Appropriate	⦿⦿⦿
CT neck without IV contrast	May Be Appropriate (Disagreement)	⦿⦿⦿
CTA chest with IV contrast	May Be Appropriate	⦿⦿⦿
CT neck and chest with IV contrast	May Be Appropriate	⦿⦿⦿⦿
CT neck and chest without IV contrast	May Be Appropriate	⦿⦿⦿⦿
FDG-PET/CT skull base to mid-thigh	May Be Appropriate	⦿⦿⦿⦿
Radiography neck	Usually Not Appropriate	⦿⦿
MRI chest without and with IV contrast	Usually Not Appropriate	○
MRI chest without IV contrast	Usually Not Appropriate	○
CT chest without and with IV contrast	Usually Not Appropriate	⦿⦿⦿
CT neck with IV contrast	Usually Not Appropriate	⦿⦿⦿
CT neck without and with IV contrast	Usually Not Appropriate	⦿⦿⦿
CT neck and chest without and with IV contrast	Usually Not Appropriate	⦿⦿⦿⦿

Variant 3. Adult. Clinically suspected tracheomalacia or bronchomalacia. Initial imaging.

Procedure	Appropriateness Category	Relative Radiation Level
CT chest without IV contrast	Usually Appropriate	⚙️⚙️⚙️
Radiography chest	May Be Appropriate (Disagreement)	⚙️
CT neck and chest without IV contrast	May Be Appropriate (Disagreement)	⚙️⚙️⚙️⚙️
Radiography neck	Usually Not Appropriate	⚙️⚙️
MRI chest without and with IV contrast	Usually Not Appropriate	○
MRI chest without IV contrast	Usually Not Appropriate	○
CT chest with IV contrast	Usually Not Appropriate	⚙️⚙️⚙️
CT chest without and with IV contrast	Usually Not Appropriate	⚙️⚙️⚙️
CT neck with IV contrast	Usually Not Appropriate	⚙️⚙️⚙️
CT neck without and with IV contrast	Usually Not Appropriate	⚙️⚙️⚙️
CT neck without IV contrast	Usually Not Appropriate	⚙️⚙️⚙️
CTA chest with IV contrast	Usually Not Appropriate	⚙️⚙️⚙️
CT neck and chest with IV contrast	Usually Not Appropriate	⚙️⚙️⚙️⚙️
CT neck and chest without and with IV contrast	Usually Not Appropriate	⚙️⚙️⚙️⚙️
FDG-PET/CT skull base to mid-thigh	Usually Not Appropriate	⚙️⚙️⚙️⚙️

Variant 4. Adult. Tracheomalacia or bronchomalacia. Pre- or posttreatment assessment.

Procedure	Appropriateness Category	Relative Radiation Level
CT chest without IV contrast	Usually Appropriate	⚙️⚙️⚙️
CT chest with IV contrast	May Be Appropriate	⚙️⚙️⚙️
CTA chest with IV contrast	May Be Appropriate	⚙️⚙️⚙️
CT neck and chest with IV contrast	May Be Appropriate	⚙️⚙️⚙️⚙️
CT neck and chest without IV contrast	May Be Appropriate	⚙️⚙️⚙️⚙️
Radiography chest	Usually Not Appropriate	⚙️
Radiography neck	Usually Not Appropriate	⚙️⚙️
MRI chest without and with IV contrast	Usually Not Appropriate	○
MRI chest without IV contrast	Usually Not Appropriate	○
CT chest without and with IV contrast	Usually Not Appropriate	⚙️⚙️⚙️
CT neck with IV contrast	Usually Not Appropriate	⚙️⚙️⚙️
CT neck without and with IV contrast	Usually Not Appropriate	⚙️⚙️⚙️
CT neck without IV contrast	Usually Not Appropriate	⚙️⚙️⚙️
CT neck and chest without and with IV contrast	Usually Not Appropriate	⚙️⚙️⚙️⚙️
FDG-PET/CT skull base to mid-thigh	Usually Not Appropriate	⚙️⚙️⚙️⚙️

Variant 5. Adult. Clinically suspected bronchiectasis. Initial imaging.

Procedure	Appropriateness Category	Relative Radiation Level
Radiography chest	Usually Appropriate	⦿
CT chest without IV contrast	Usually Appropriate	⦿⦿⦿
MRI chest without IV contrast	May Be Appropriate	○
CTA chest with IV contrast	May Be Appropriate	⦿⦿⦿
Radiography neck	Usually Not Appropriate	⦿⦿
MRI chest without and with IV contrast	Usually Not Appropriate	○
CT chest with IV contrast	Usually Not Appropriate	⦿⦿⦿
CT chest without and with IV contrast	Usually Not Appropriate	⦿⦿⦿
CT neck with IV contrast	Usually Not Appropriate	⦿⦿⦿
CT neck without and with IV contrast	Usually Not Appropriate	⦿⦿⦿
CT neck without IV contrast	Usually Not Appropriate	⦿⦿⦿
CT neck and chest with IV contrast	Usually Not Appropriate	⦿⦿⦿⦿
CT neck and chest without and with IV contrast	Usually Not Appropriate	⦿⦿⦿⦿
CT neck and chest without IV contrast	Usually Not Appropriate	⦿⦿⦿⦿
FDG-PET/CT skull base to mid-thigh	Usually Not Appropriate	⦿⦿⦿⦿

Variant 6. Adult. Bronchiectasis. Assessment of complications or treatment response.

Procedure	Appropriateness Category	Relative Radiation Level
Radiography chest	Usually Appropriate	⦿
CT chest without IV contrast	Usually Appropriate	⦿⦿⦿
CT chest with IV contrast	May Be Appropriate	⦿⦿⦿
CTA chest with IV contrast	May Be Appropriate	⦿⦿⦿
Radiography neck	Usually Not Appropriate	⦿⦿
MRI chest without and with IV contrast	Usually Not Appropriate	○
MRI chest without IV contrast	Usually Not Appropriate	○
CT chest without and with IV contrast	Usually Not Appropriate	⦿⦿⦿
CT neck with IV contrast	Usually Not Appropriate	⦿⦿⦿
CT neck without and with IV contrast	Usually Not Appropriate	⦿⦿⦿
CT neck without IV contrast	Usually Not Appropriate	⦿⦿⦿
CT neck and chest with IV contrast	Usually Not Appropriate	⦿⦿⦿⦿
CT neck and chest without and with IV contrast	Usually Not Appropriate	⦿⦿⦿⦿
CT neck and chest without IV contrast	Usually Not Appropriate	⦿⦿⦿⦿
FDG-PET/CT skull base to mid-thigh	Usually Not Appropriate	⦿⦿⦿⦿

Table 1. Appropriateness category names and definitions

Appropriateness Category Name	Appropriateness Rating	Appropriateness Category Definition
Usually Appropriate	7, 8, or 9	The imaging procedure or treatment is indicated in the specified clinical scenarios at a favorable risk-benefit ratio for patients.
May Be Appropriate	4, 5, or 6	The imaging procedure or treatment may be indicated in the specified clinical scenarios as an alternative to imaging procedures or treatments with a more favorable risk-benefit ratio, or the risk-benefit ratio for patients is equivocal.
May Be Appropriate (Disagreement)	5	The individual ratings are too dispersed from the panel median. The different label provides transparency regarding the panel's recommendation. "May be appropriate" is the rating category and a rating of 5 is assigned.
Usually Not Appropriate	1, 2, or 3	The imaging procedure or treatment is unlikely to be indicated in the specified clinical scenarios, or the risk-benefit ratio for patients is likely to be unfavorable.

Table 2. Relative radiation level designations

RRL	Adult Effective Dose Estimate Range (mSv)	Pediatric Effective Dose Estimate Range (mSv)
0	0	0
⦿	<0.1	<0.03
⦿⦿	0.1-1	0.03-0.3
⦿⦿⦿	1-10	0.3-3
⦿⦿⦿⦿	10-30	3-10
⦿⦿⦿⦿⦿	30-100	10-30

Note: Relative radiation level (RRL) assignments for some of the examinations cannot be made, because the actual patient doses in these procedures vary as a function of a number of factors (eg, region of the body exposed to ionizing radiation, the imaging guidance that is used). The RRLs for these examinations are designated as "varies."

SUMMARY OF LITERATURE REVIEW

Introduction/Background

Tracheal stenosis can be caused by a wide variety of neoplastic and nonneoplastic etiologies; symptoms can include cough, dyspnea, stridor, or wheezing [1-3]. Treatment of tracheal stenosis can include stent placement, dilation, ablation, surgical resection, and/or systemic treatment of the underlying condition [1]. Excessive narrowing of the trachea, central bronchi, or both at expiration is known as expiratory central airway collapse (ECAC); chronic cough and dyspnea are the most frequent symptoms. The terms "tracheomalacia" and "tracheobronchomalacia" refer to abnormalities in airway cartilage affecting primarily the anterior and lateral portions of the trachea, correlating with a lateral splaying and collapse of the trachea at expiration, although the term "excessive dynamic airway collapse" refers to isolated excessive anterior bowing of the posterior membranous tracheal wall with tracheal narrowing [4]. ECAC is often occult at inspiration, but an inspiratory elongated transverse diameter of the trachea—also known as a

"lunate" or "lemon" shape—is highly correlated with tracheomalacia as confirmed by expiratory CT [2,4]. Some forms of ECAC may be present in up to 10% of symptomatic patients undergoing bronchoscopy [5], and ECAC can be associated with symptoms such as chronic cough and dyspnea and with a decreased quality of life [6,7]. Symptomatic ECAC can be treated with tracheobronchial stenting, but surgical treatment with tracheoplasty or tracheobronchoplasty after a stent trial is considered the definitive treatment [4,8].

Bronchiectasis is defined as irreversible abnormal bronchial dilatation, with patients most commonly presenting with chronic productive cough. Although a wide range of congenital and acquired conditions can be associated with bronchiectasis, a common etiologic pathway is thought to be impairment of normal bronchial clearance and airway immune mechanisms, resulting in recurrent infections and chronic bronchial inflammation that cause bronchial injury and dilatation [9,10]. The prevalence of bronchiectasis has increased worldwide over the last few decades; in the United States, prevalence has been estimated as

approximately 139 per 100,000 individuals [9]. Treatment includes preventive airway clearance therapies, anti-inflammatory agents, prophylactic or therapeutic antibiotics, and, in severe cases, surgical resection or lung transplantation.

Special Imaging Considerations

In cases of tracheal stenosis and central airway lesions in general, special CT reformatting techniques such as 2-D multiplanar, 3-D volume-rendered, and virtual bronchoscopic images may be helpful for illustration of findings and preprocedural planning [11-13]. For example, coronal and sagittal 2-D reformatted images and 3-D volume reformatted images can depict the craniocaudal extent of lesions and distance from landmarks such as the vocal cords and carina, and virtual bronchoscopic images can illustrate the expected endoluminal appearance of lesions and provide guidance for bronchoscopy and procedures by demonstrating local airway anatomy. Minimum intensity projection reformatted images can also display central airway abnormalities and bronchiectasis [10].

Modern multidetector CT can be used to image the entire trachea at end expiration or during forced expiration (dynamic expiratory imaging). More recently, 320-row multidetector CT scanners have enabled cinematic 4-D volumetric images of the trachea, allowing time-resolved coverage of the entire trachea throughout an inspiratory/expiratory cycle [14,15]. Low-dose volumetric CT using 40 to 80 mA is comparable to standard higher-dose techniques in demonstrating degree of trachea collapse [16], and low-dose techniques have been widely adopted for dynamic expiratory imaging assessment of ECAC [17,18].

Optimal evaluation of the airways requires thin-section imaging with a slice thickness of 1.5 mm or thinner. Larger slice thicknesses cause partial volume averaging that can obscure airway anatomy and airway lesions. Adequate breath holding at inspiration is also important, because respiratory motion can also obscure airway lesions and can also cause an erroneous impression of bronchiectasis caused by volume averaging and image blurring.

Initial Imaging Definition

Initial imaging is defined as imaging at the beginning of the care episode for the medical condition defined by the variant. More than one procedure can be considered usually appropriate in the initial imaging evaluation when:

- There are procedures that are equivalent alternatives (ie, only one procedure will be ordered to provide the clinical information to effectively manage the patient's care)
OR
- There are complementary procedures (ie, more than one procedure is ordered as a set or simultaneously where each

procedure provides unique clinical information to effectively manage the patient's care).

DISCUSSION OF PROCEDURES BY VARIANT

Variant 1: Adult. Clinically suspected tracheal or bronchial stenosis. Initial imaging

CT Chest With IV Contrast. Chest CT is widely used for first-line imaging evaluation of central airway pathology such as masses, thickening, and stenosis. CT with intravenous (IV) contrast provides the advantage of evaluation of enhancement characteristics and optimal evaluation of hilar and mediastinal adenopathy [19]; however, relevant studies comparing contrast-enhanced CT with unenhanced CT are lacking. CT has shown a high correlation with findings at bronchoscopy and offers additional advantages by depicting degree of stenosis, extraluminal involvement of lesions, and extension to adjacent structures [19-21]. CT allows assessment of the location, shape, dimensions, mural extent, and attenuation characteristics of tumors of the large airways and detection of intrathoracic disease in cases of malignancy [19,20].

Multiplanar reconstruction (MPR) and virtual bronchoscopy (VB) have been shown to be helpful adjuncts to axial CT reconstructions for both chest CT with and without IV contrast [22,23]. In a prospective study of 56 patients with central airway stenosis that compared thin-section CT axial images, MPR, VB, and minimum intensity projection images to fiberoptic bronchoscopy (FB), MPR images had very good ($\kappa = 0.76$) and the highest agreement with FB in depicting degree of stenosis, and MPR and axial CT images had an advantage over FB in depicting the extent of distal disease [23].

CT Chest Without and With IV Contrast. There is no relevant literature to support the use of chest CT without and with IV contrast in the initial evaluation of suspected tracheal stenosis.

CT Chest Without IV Contrast. Chest CT is widely used for first-line imaging evaluation of central airway pathology such as masses, thickening, and stenosis. CT without IV contrast readily depicts central airway lesions, thickening, and stenosis. CT has shown high correlation with findings at bronchoscopy and offers additional advantages by depicting degree of stenosis, extraluminal involvement of lesions, and extension to adjacent structures [20,21]. CT allows assessment of the location, shape, dimensions, mural extent, and attenuation characteristics of tumors of the large airways and detection of intrathoracic disease in cases of malignancy [19,20].

MPR and VB have been shown to be helpful adjuncts to axial CT reconstructions for both chest CT with and without IV contrast [22,23]. In a prospective study of 56 patients with central airway stenosis that compared thin-section CT axial images, MPR, VB, and minimum intensity projection images to FB, MPR images had very good ($\kappa = 0.76$) and the highest agreement with FB in depicting degree of stenosis, and MPR and axial CT images had an advantage over FB in depicting the extent of distal disease [23].

CT Neck and Chest With IV Contrast. There is no relevant literature to support the use of neck and chest CT with IV contrast in the initial evaluation of suspected tracheal stenosis. However, combined neck and chest CT with IV contrast can be performed for assessment of suspected tracheal lesions and stenosis, especially for diseases that can involve the subglottic trachea, such as diffuse tracheal diseases and suspected or known malignancies of the neck. Chest CT protocols to evaluate tracheal stenosis often prescribe z-axis coverage through the lower neck.

CT Neck and Chest Without and With IV Contrast. There is no relevant literature to support the use of neck and chest CT without and with IV contrast in the initial evaluation of suspected tracheal stenosis.

CT Neck and Chest Without IV Contrast. There is no relevant literature to support the use of neck and chest CT without IV contrast in the initial evaluation of suspected tracheal stenosis. However, combined neck and chest CT without IV contrast may be performed for assessment of suspected tracheal lesions and stenosis, especially for diseases that can involve the subglottic trachea, such as diffuse tracheal diseases and suspected or known malignancies of the neck. Chest CT protocols to evaluate tracheal stenosis often prescribe z-axis coverage through the lower neck.

CT Neck With IV Contrast. Neck CT with IV contrast may occasionally be performed as a targeted assessment of known lesions within the superior trachea, including primary neck malignancies with tracheal involvement. However, the limited z-axis coverage of neck CT risks exclusion of the full extent of tracheal disease. More commonly, neck CT may be performed as part of a combined neck and chest CT for assessment of suspected tracheal lesions and stenosis.

CT Neck Without and With IV Contrast. There is no relevant literature to support the use of neck CT without and with IV contrast in the initial evaluation of suspected tracheal stenosis.

CT Neck Without IV Contrast. Neck CT without IV contrast may occasionally be performed as a targeted assessment of known lesions within the superior trachea, including primary neck malignancies with tracheal

involvement. However, the limited z-axis coverage of neck CT risks exclusion of the full extent of tracheal disease. More commonly, neck CT may be performed as part of a combined neck and chest CT for assessment of suspected tracheal lesions and stenosis.

CTA Chest With IV Contrast. Chest CT angiography (CTA) with IV contrast may be used in evaluation of suspected tracheal stenosis in the setting of extrinsic compression due to a vascular cause, such as aberrant vessel or aneurysm. However, there is no relevant evidence comparing chest CTA and standard chest CT with or without IV contrast in initial evaluation of suspected tracheal stenosis.

FDG-PET/CT Skull Base to Mid-Thigh. Fluorine-18-2-fluoro-2-deoxy-D-glucose (FDG)-PET/CT is often used in the initial staging and follow-up of known thoracic malignancies, including tracheal tumors. However, FDG-PET/CT is not usually obtained as the initial imaging assessment of suspected tracheal stenosis.

MRI Chest Without and With IV Contrast. Although tracheal imaging can be performed with MRI, including dynamic imaging, this tool has been used mainly as a research tool.

MRI Chest Without IV Contrast. Although tracheal imaging can be performed with MRI, including dynamic imaging, this tool has been used mainly as a research tool.

Radiography Chest. Radiography is often performed as initial imaging in patients with respiratory symptoms. Although tracheal stenosis and masses are occasionally incidental findings at chest radiography, the modality is much less sensitive for detection of central airway pathology than cross-sectional imaging. In a study of 41 patients with tumors and nonneoplastic stenosis of the central airways, radiography performed poorly compared to CT in depicting and characterizing lesions [22]. Radiography may be useful as an evaluation of possible complications of central airway disease, such as postobstructive atelectasis or pneumonia.

Radiography Neck. There is no relevant literature to support the use of neck radiography in the initial evaluation of suspected tracheal stenosis. Radiography of the neck may be obtained in patients with suspected upper airway obstruction due to certain infections or foreign bodies. However, it is not routinely used for evaluation of tracheal stenosis.

Variant 2: Adult. Tracheal or bronchial stenosis. Pre- or posttreatment assessment

CT Chest With IV Contrast. CT of the chest with IV contrast can be used for pretreatment assessment of lesions and stenosis of the large airways and can help determine

suitability and type of surgical or nonsurgical treatment approach [24]. However, studies comparing performance of chest CT with IV contrast to chest CT without IV contrast for evaluation of tracheal stenosis and associated lesions are lacking. A few small studies have documented additional incremental benefits of review of 2-D multiplanar, 3-D reformatted, and VB images, including changes in surgical approach or identification of associated findings such as small fistulae [11]. Chest CT is also used for evaluation of suspected posttreatment complications of tracheal interventions.

CT is commonly used for planning for tracheal stent implantation; a study of 69 patients with stenosis due to malignancy used CT to select stent diameter by measuring proximal and distal landing zone diameters and to determine desired stent length by measuring length of the involved segment [25]. A small study of 17 stenoses in 14 patients with postintubation stenosis confirmed at surgery found a detection rate of stenosis of 94% (16 of 17 lesions) of CT with VB and 88% (15 of 17) by rigid bronchoscopy; assessment of length was accurate for 87% of stenotic segments by CT and VB and 73% of segments by rigid bronchoscopy [13].

In a study of contrast-enhanced CT of 46 adenoid cystic carcinomas of the trachea and 36 other tracheal tumors, several imaging characteristics were predictive of poor disease-free survival, including longitudinal length >34 mm, transmural growth, and transverse length >20 mm, although only the latter remained significant in multivariate analysis [19].

A retrospective study of 31 tumors of the trachea or main bronchi compared a combination of pre- and post-contrast CT axial images, volume-rendered, and VB post-processing techniques with surgical and pathology findings, finding good correlations for tumor locations, morphologies, longitudinal involvement, extent and morphology of stenosis, extramural invasion, and distance from the carina [12]. In a study of 52 patients comparing VB with bronchoscopy, VB had a high sensitivity and accuracy (both 93%) for detection of central airway tumors and had a high sensitivity (90%) and accuracy (96%) for characterization of airway stenosis [26].

However, there is no relevant literature specifically comparing chest CT with IV contrast to chest CT without IV contrast.

CT Chest Without and With IV Contrast. There is no relevant literature to support the use of chest CT without and with IV contrast for pre- or posttreatment evaluation of tracheal stenosis.

CT Chest Without IV Contrast. CT of the chest without IV contrast is widely used for pretreatment

assessment of lesions and stenosis of the large airways and can help determine suitability and type of surgical or nonsurgical treatment approach [24]. A few small studies have documented additional incremental benefits of review of 2-D multiplanar, 3-D reformatted, and VB images, including changes in surgical approach or identification of associated findings such as small fistulae [11]. Chest CT is also used for evaluation of suspected posttreatment complications of tracheal interventions.

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CT Neck and Chest With IV Contrast. Combined neck and chest CT with IV contrast can be performed for pre- or posttreatment evaluation of tracheal stenosis, especially for diseases that can involve the subglottic trachea, such as diffuse tracheal diseases and suspected or known malignancies of the neck. Chest CT protocols to evaluate tracheal stenosis often prescribe z-axis coverage through the lower neck.

CT Neck and Chest Without and With IV Contrast. There is no relevant literature to support the use of neck and chest CT without and with IV contrast for pre- or posttreatment evaluation of tracheal stenosis.

CT Neck and Chest Without IV Contrast. Combined neck and chest CT without IV contrast can be performed for pre- or posttreatment evaluation of tracheal stenosis, especially for diseases that can involve the subglottic trachea, such as diffuse tracheal diseases and suspected or known

malignancies of the neck. Chest CT protocols to evaluate tracheal stenosis often prescribe z-axis coverage through the lower neck.

CT Neck With IV Contrast. Neck CT with IV contrast may occasionally be performed as a targeted assessment of known lesions within the superior trachea, including primary neck malignancies with tracheal involvement. However, the limited z-axis coverage of neck CT risks exclusion of the full extent of tracheal disease. More commonly, neck CT may be performed as part of a combined neck and chest CT for pre- or posttreatment assessment of tracheal lesions and stenosis.

CT Neck Without and With IV Contrast. There is no relevant literature to support the use of neck CT without and with IV contrast for pre- or posttreatment evaluation of tracheal stenosis.

CT Neck Without IV Contrast. Neck CT without IV contrast may occasionally be performed as a targeted assessment of known lesions within the superior trachea, including primary neck malignancies with tracheal involvement. However, the limited z-axis coverage of neck CT risks exclusion of the full extent of tracheal disease. More commonly, neck CT may be performed as part of a combined neck and chest CT for pre- or posttreatment assessment of tracheal lesions and stenosis.

CTA Chest With IV Contrast. Chest CTA with IV contrast may be used in preoperative evaluation of tracheal stenosis in the setting of extrinsic compression due to a vascular cause, such as aberrant vessel or aneurysm. Chest CTA with aortic contrast phase timing may be used in selected cases to evaluate suspected bleeding as a complication of tracheal interventions.

FDG-PET/CT Skull Base to Mid-Thigh. FDG-PET/CT is often used in the initial staging and follow-up of known thoracic malignancies, including tracheal tumors. A small retrospective study of 13 patients assessed FDG-PET/CT findings of pathologically proven tracheal tumors, finding a soft tissue mass with FDG uptake and standardized uptake value of >2.5 in all cases (range 2.7-20.5) [27]. A retrospective FDG-PET study of 37 patients with primary malignant tracheal tumors showed a lower overall survival rate for tumors with a higher “metabolic tumor volume,” defined as tumor area with ≥ 2.5 standardized uptake value, and greater “total lesion glycolysis,” defined as metabolic tumor volume \times mean standardized uptake value [28].

MRI Chest Without and With IV Contrast. Although tracheal imaging can be performed with MRI, including dynamic imaging, this tool has been used mainly as a research tool.

MRI Chest Without IV Contrast. Although tracheal imaging can be performed with MRI, including dynamic imaging, this tool has been used mainly as a research tool.

Radiography Chest. There is no relevant literature to support the use of chest radiography for pretreatment evaluation of tracheal stenosis. Although there is no relevant literature to support the routine use of chest radiographs after procedures designed to treat tracheal stenosis, in practice chest radiographs may be obtained to evaluate possible complications such as pneumothorax, excessive pneumomediastinum, or aspiration.

Radiography Neck. There is no relevant literature to support the use of neck radiography for pre- or posttreatment evaluation of tracheal stenosis.

Variant 3: Adult. Clinically suspected tracheomalacia or bronchomalacia. Initial imaging

CT Chest With IV Contrast. There is no relevant literature to support the use of chest CT with IV contrast for initial evaluation of suspected tracheomalacia or bronchomalacia.

CT Chest Without and With IV Contrast. There is no relevant literature to support the use of chest CT without and with IV contrast for initial evaluation of suspected tracheomalacia or bronchomalacia.

CT Chest Without IV Contrast. Chest CT without IV contrast is useful for noninvasive imaging of ECAC, including tracheobronchomalacia and excessive dynamic airway collapse. Chest CT during forced expiration has been widely adopted as the primary imaging protocol because it is more sensitive for detection of ECAC, eliciting greater degrees of expiratory collapse than CT obtained at end expiration [29-31]. In a study of 29 patients with suspected ECAC, forced expiratory dynamic cine imaging showed tracheal collapse $>50\%$ at 38% of assessed levels compared to 13% at end-expiratory CT [32]; a study of 67 patients with chronic obstructive pulmonary disease (COPD) showed a mean tracheal collapse of 62% at forced expiratory CT and only 17% at end expiratory CT [31]. Fifty percent area narrowing of the lumen of the trachea on CT at expiration had originally been considered suggestive of ECAC, but a threshold of 70% collapse is now proposed following a study by Boiselle et al [17], finding $>50\%$ collapse in 40 of 51 (78%) healthy volunteers.

CT Neck and Chest With IV Contrast. There is no relevant literature to support the use of neck and chest CT

with IV contrast for initial evaluation of suspected tracheomalacia or bronchomalacia.

CT Neck and Chest Without and With IV Contrast. There is no relevant literature to support the use of neck and chest CT without and with IV contrast for initial evaluation of suspected tracheomalacia or bronchomalacia.

CT Neck and Chest Without IV Contrast. There is no relevant literature to support performing a full neck CT in this setting; however, z-axis coverage through the lower neck is often prescribed as part of a standard chest CT without IV contrast for evaluation of suspected tracheomalacia or bronchomalacia.

CT Neck With IV Contrast. There is no relevant literature to support the use of neck CT with IV contrast for initial evaluation of suspected tracheomalacia or bronchomalacia.

CT Neck Without and With IV Contrast. There is no relevant literature to support the use of neck CT without and with IV contrast for initial evaluation of suspected tracheomalacia or bronchomalacia.

CT Neck Without IV Contrast. There is no relevant literature to support the use of neck CT without IV contrast for initial evaluation of suspected tracheomalacia or bronchomalacia.

CTA Chest With IV Contrast. There is no relevant literature to support the use of chest CTA for initial evaluation of suspected tracheomalacia or bronchomalacia.

FDG-PET/CT Skull Base to Mid-Thigh. There is no relevant literature to support the use of FDG-PET/CT for initial evaluation of suspected tracheomalacia or bronchomalacia.

MRI Chest Without and With IV Contrast. There is no relevant literature to support the use of MRI chest without and with IV contrast for initial evaluation of suspected tracheomalacia or bronchomalacia.

MRI Chest Without IV Contrast. Cine MRI without IV contrast with dynamic expiratory imaging has been used in several small studies to depict tracheal dynamics during inspiration and expiration; a small study of 3 patients with COPD and 9 healthy patients showed very good correlation ($K = 0.81$) for dynamic expiratory tracheal area measurements [33]. An observational study evaluated 15 nonsmokers and 23 smokers with COPD with cine MRI, finding greater expiratory tracheal area collapse in the patients with COPD [32]. However, larger studies using MRI in patients suspected of ECAC are not yet available, and use of dynamic

tracheal MRI is currently limited to research settings and a few academic centers.

Radiography Chest. Dynamic chest radiography has been proposed for evaluating ECAC but use has been limited to small preliminary research investigations [34]. Chest radiography may be used in the initial evaluation of other pulmonary diseases that may manifest with respiratory symptoms also seen in ECAC.

Radiography Neck. There is no relevant literature to support the use of neck radiography for initial evaluation of suspected tracheomalacia or bronchomalacia.

Variant 4: Adult. Tracheomalacia or bronchomalacia. Pre- or posttreatment assessment

CT Chest With IV Contrast. There is no relevant literature to support the use of chest CT with IV contrast for pre- or posttreatment evaluation of tracheomalacia or bronchomalacia. In practice, chest CT may be performed with IV contrast in evaluation of postsurgical complications of procedures used to treat tracheomalacia or bronchomalacia.

CT Chest Without and With IV Contrast. There is no relevant literature to support the use of chest CT without and with IV contrast for pre- or posttreatment evaluation of tracheomalacia or bronchomalacia.

CT Chest Without IV Contrast. Evaluation of ECAC with dynamic expiratory CT can change treatment approach in some patients compared with evaluation with bronchoscopy alone and is standardly performed without IV contrast. In one study, a change in planned treatment was performed in 12 of 29 patients with tracheomalacia or bronchomalacia who had previously undergone bronchoscopy, including changes in surgical approach [30].

A small study using inspiratory and dynamic expiratory CT to evaluate 5 patients with tracheomalacia before and after tracheobronchoplasty found a decrease in degree of tracheal collapse after surgery in all participants [35]. Other studies of 18 patients [8] and 16 patients [36] with tracheobronchomalacia using end inspiratory and dynamic expiratory CT showed significant average decreases in percentage collapse of the trachea after tracheobronchoplasty. However, there are no guidelines for performing routine follow-up of patients after treatment for ECAC.

CT Neck and Chest With IV Contrast. Z-axis coverage through the lower neck is often prescribed as part of a standard chest CT with IV contrast for evaluation of

suspected tracheomalacia or bronchomalacia, but there is no relevant evidence to support performing a full neck CT in this setting. In clinical practice, neck CT may be performed in conjunction with chest CT to evaluate suspected complications of tracheal interventions.

CT Neck and Chest Without and With IV Contrast. There is no relevant literature to support the use of neck and chest CT without and with IV contrast for pre- or posttreatment evaluation of tracheomalacia or bronchomalacia.

CT Neck and Chest Without IV Contrast. Z-axis coverage through the lower neck is often prescribed as part of a standard chest CT without IV contrast for evaluation of suspected tracheomalacia or bronchomalacia, but there is no relevant evidence to support performing a full neck CT in this setting. In clinical practice, neck CT may be performed in conjunction with chest CT to evaluate suspected complications of tracheal interventions.

CT Neck With IV Contrast. There is no relevant literature to support the use of neck CT with IV contrast for pre- or posttreatment evaluation of tracheomalacia or bronchomalacia.

CT Neck Without and With IV Contrast. There is no relevant literature to support the use of neck CT without and with IV contrast for pre- or posttreatment evaluation of tracheomalacia or bronchomalacia.

CT Neck Without IV Contrast. There is no relevant literature to support the use of neck CT without IV contrast for pre- or posttreatment evaluation of tracheomalacia or bronchomalacia.

CTA Chest With IV Contrast. There is no relevant literature to support the use of chest CTA for pre- or posttreatment evaluation of tracheomalacia or bronchomalacia. However, chest CTA timed for an aortic phase of contrast may be used in selected cases to evaluate suspected bleeding as a complication of tracheal interventions.

FDG-PET/CT Skull Base to Mid-Thigh. There is no relevant literature to support the use of FDG-PET/CT for pre- or posttreatment evaluation of tracheomalacia or bronchomalacia.

MRI Chest Without and With IV Contrast. There is no relevant literature to support the use of MRI chest without and with IV contrast for pre- or posttreatment evaluation of tracheomalacia or bronchomalacia.

MRI Chest Without IV Contrast. There is no relevant literature to support the use of chest MRI for posttreatment evaluation of tracheomalacia or bronchomalacia. Cine MRI

without IV contrast with dynamic expiratory imaging has been used in several small studies to depict tracheal dynamics during inspiration and expiration; a small study of 3 patients with COPD and 9 healthy patients showed very good correlation ($\kappa = 0.81$) for dynamic expiratory tracheal area measurements [33]. An observational study evaluated 15 nonsmokers and 23 smokers with COPD with cine MRI, finding greater expiratory tracheal area collapse in the patients with COPD [32]. However, larger studies using MRI in patients suspected of ECAC are not yet available, and use of dynamic tracheal MRI is currently limited to research settings and a few academic centers.

Radiography Chest. Although there is no relevant literature to support the routine use of chest radiographs after procedures designed to treat tracheomalacia or bronchomalacia, in practice, chest radiographs may be obtained to evaluate possible complications such as pneumothorax, excessive pneumomediastinum, or aspiration.

Radiography Neck. There is no relevant literature to support the use of neck radiography for pre- or posttreatment evaluation of tracheomalacia or bronchomalacia.

Variant 5: Adult. Clinically suspected bronchiectasis. Initial imaging

CT Chest With IV Contrast. There is no relevant literature to support the use of chest CT with IV contrast for initial evaluation of suspected bronchiectasis. However, bronchiectasis can be detected incidentally on chest CT with IV contrast performed for other indications.

CT Chest Without and With IV Contrast. There is no relevant literature to support the use of chest CT without and with IV contrast for initial evaluation of suspected bronchiectasis.

CT Chest Without IV Contrast. Chest CT without IV contrast is useful for detection of bronchiectasis, characterized by bronchi larger than adjacent arteries of the same order, lack of normal bronchial tapering from central to peripheral lung, or identification of bronchi within 1 cm of the pleural surface [37]. Although routine chest CT protocols can demonstrate dilated bronchi, thin-section interstitial lung disease CT protocols with ≤ 1.5 mm slice thickness may be used to identify and characterize a variety of diffuse chronic lung diseases associated with bronchiectasis.

The 2010 British Thoracic Society guidelines for non-cystic fibrosis (non-CF) bronchiectasis recommend thin-section CT, either conventional high-resolution CT or volumetric thin-slice CT, as the preferred examination for evaluation of suspected bronchiectasis. The guidelines

acknowledge that, although certain CT distributions and appearances of bronchiectasis may suggest a particular etiology, in many cases, findings are not pathognomonic, as confirmed by the relatively low reader diagnostic performance in several retrospective CT studies [38-41]. However, CT can play a role in suggesting further clinical evaluation of causes of bronchiectasis and associated findings, such as in prompting testing for nontuberculous mycobacterial infection (NTMB) in the appropriate clinical setting [42].

CT can be used to quantify the extent and severity of bronchiectasis using a variety of techniques and software. A systematic review of 122 studies found 42 quantitative CT scoring methods in the research literature, including calculation of bronchial-arterial ratios, bronchial diameters, or bronchial surface area [43]. Severity of bronchiectasis at CT correlates with measures of airflow obstruction [40]. A relatively large prospective cohort study of 608 patients with bronchiectasis examined the association between a variety of clinical, laboratory, and CT findings and clinical outcomes; a CT finding of bronchiectasis in at least 3 lobes was associated with poorer outcomes and was incorporated along with several clinical variables into a bronchiectasis severity score with relatively high predictive value for exacerbations, hospitalizations, and mortality in patients with bronchiectasis [44]. A prospective multicenter study of 261 patients with non-CF bronchiectasis found weak but statistically significant correlations between severity and extent of bronchiectasis at CT and forced expiratory volume in one second and forced vital capacity [45]. A study of 277 patients with NTMB found correlations between bronchiectasis (as assessed by semiquantitative scores) and clinical variables such as more frequent exacerbations and lower blood oxygenation [46].

CT Neck and Chest With IV Contrast. There is no relevant literature to support the use of neck and chest CT with IV contrast for initial evaluation of suspected bronchiectasis.

CT Neck and Chest Without and With IV Contrast. There is no relevant literature to support the use of neck and chest CT without and with IV contrast for initial evaluation of suspected bronchiectasis.

CT Neck and Chest Without IV Contrast. There is no relevant literature to support the use of neck and chest CT without IV contrast for initial evaluation of suspected bronchiectasis.

CT Neck With IV Contrast. There is no relevant literature to support the use of neck CT with IV contrast for initial evaluation of suspected bronchiectasis.

CT Neck Without and With IV Contrast. There is no relevant literature to support the use of neck CT without and with IV contrast for initial evaluation of suspected bronchiectasis.

CT Neck Without IV Contrast. There is no relevant literature to support the use of neck CT without IV contrast for initial evaluation of suspected bronchiectasis.

CTA Chest With IV Contrast. There is no relevant literature to support the use of chest CTA for initial evaluation of suspected bronchiectasis. However, bronchiectasis can be detected incidentally on chest CTA with IV contrast performed for other indications.

FDG-PET/CT Skull Base to Mid-Thigh. There is no relevant literature to support the use of FDG-PET/CT for initial evaluation of suspected bronchiectasis.

MRI Chest Without and With IV Contrast. There is no relevant literature to support the use of MRI chest without and with IV contrast for initial evaluation of suspected bronchiectasis.

MRI Chest Without IV Contrast. Limited data exist on the use of MRI without IV contrast in characterization of bronchiectasis. A small study of 23 adults with primary immunodeficiency found MRI inferior to CT in characterizing extent of bronchiectasis but found similar performance of MRI and CT in assessing severity of bronchiectasis, mucous plugging, bronchial wall thickening, and other associated parenchymal findings [47]. An exploratory study of 25 patients showed moderate agreement between MRI and CT scores for imaging findings in mycobacterium avium complex pneumonia, including for bronchiectasis [48]. However, the use of MRI for assessment of bronchiectasis is currently limited mainly to research settings or use in young patients such as those with cystic fibrosis.

Radiography Chest. Chest radiography is relatively insensitive for detection of bronchiectasis but is often performed as initial imaging in patients with respiratory symptoms that are common in patients with bronchiectasis [9,10]. Chest radiography may be useful for the initial evaluation of the lung parenchyma in conditions associated with bronchiectasis, but it provides limited characterization of severity and morphology of bronchiectasis. The 2010 British Thoracic Society guidelines for non-CF bronchiectasis recommend a baseline chest radiograph in all patients with suspected bronchiectasis but recommend repeat radiographs only if clinically warranted [40].

Radiography Neck. There is no relevant literature to support the use of neck radiography for initial evaluation of suspected bronchiectasis.

Variant 6: Adult. Bronchiectasis. Assessment of complications or treatment response

CT Chest With IV Contrast. There is no relevant literature to support the use of chest CT with IV contrast in the evaluation of bronchiectasis complications or treatment response. CT chest with IV contrast may also be appropriate in the setting of suspected acute infection and associated complications such as abscess or necrosis.

CT Chest Without and With IV Contrast. There is no relevant literature to support the use of chest CT without and with IV contrast in the evaluation of bronchiectasis complications or treatment response.

CT Chest Without IV Contrast. Chest CT without IV contrast may be used to evaluate complications associated with bronchiectasis, including pneumonia and hemoptysis, and is often used in follow-up of conditions associated with bronchiectasis, such as chronic infections or interstitial lung diseases. Chest CT without IV contrast may be appropriate for assessing patients with known bronchiectasis and a change in clinical status to exclude pulmonary causes [40].

Chest CT without IV contrast can be used to quantify extent and severity of bronchiectasis with special software. A systematic review of 122 studies found 42 quantitative CT scoring methods in the research literature, including calculation of bronchial-arterial ratios, bronchial diameters, or bronchial surface area [43]. Severity of bronchiectasis at CT correlates with measures of airflow obstruction [40].

Although well-established guidelines on imaging follow-up of bronchiectasis are lacking, in practice, patients with diseases associated with bronchiectasis may be assessed with CT to help guide therapy and to provide prognostic information. Patients with NTMB may be followed with chest CT to assess response to therapy or worsening of disease. A study of 210 patients with NTMB found that higher CT severity scores (a combined assessment of nodules, bronchiectasis, cavities, and consolidation) were associated with higher organism sputum counts and worse prognosis [49]; higher sputum organism count was also associated with CT findings of small nodules, consolidation, bronchiectasis, and pleural thickening in another study of 50 patients with NTMB [50]. In a study of 488 patients with NTMB, patients with predominantly fibrocavitary disease were more likely to experience clinical deterioration than those with primarily noncavitary manifestations [51]. In a study of 40 patients with NTMB lung disease not undergoing antimycobacterial treatment, 39 (98%) showed worsening

on chest CT findings over the course of several years [52], although another study of 475 patients with NTMB pulmonary disease showed improvement in CT scores with antibiotic treatment [53]. In a study of 67 patients with NTMB, more extensive total lung involvement and higher cavitary volume were independently associated with worse pulmonary function [54].

CT may be useful for follow-up of patients with bronchiectasis who may be at risk of developing NTMB. A study of 221 patients with bronchiectasis found new-onset NTMB pulmonary disease in 31 (14%) patients, which was associated with worsening of bronchiectasis, bronchiolitis, and other nodules on CT [55], and another study of 84 patients showed that more severe bronchiectasis and presence of cavities were more likely in NTMB pulmonary disease than in asymptomatic colonization [42]. Some studies have also found an association of CT severity scores and likelihood of NTMB treatment failure [56].

CT Neck and Chest With IV Contrast. There is no relevant literature to support the use of neck and chest CT with IV contrast in the evaluation of bronchiectasis complications or treatment response.

CT Neck and Chest Without and With IV Contrast. There is no relevant literature to support the use of neck and chest CT without and with IV contrast in the evaluation of bronchiectasis complications or treatment response.

CT Neck and Chest Without IV Contrast. There is no relevant literature to support the use of neck and chest CT without IV contrast in the evaluation of bronchiectasis complications or treatment response.

CT Neck With IV Contrast. There is no relevant literature to support the use of neck CT with IV contrast in the evaluation of bronchiectasis complications or treatment response.

CT Neck Without and With IV Contrast. There is no relevant literature to support the use of neck CT without and with IV contrast in the evaluation of bronchiectasis complications or treatment response.

CT Neck Without IV Contrast. There is no relevant literature to support the use of neck CT without IV contrast in the evaluation of bronchiectasis complications or treatment response.

CTA Chest With IV Contrast. There is no relevant literature to support the use of chest CTA for assessment of other bronchiectasis complications or treatment response. However, chest CTA with IV contrast with aortic contrast phase timing may be used to evaluate possible sources of hemoptysis in patients with bronchiectasis, such as in cystic fibrosis.

FDG-PET/CT Skull Base to Mid-Thigh. There is no relevant literature to support the use of FDG-PET/CT in the evaluation of bronchiectasis complications or treatment response.

MRI Chest Without and With IV Contrast. There is no relevant literature to support the use of chest MRI without and with IV contrast in the evaluation of bronchiectasis complications or treatment response.

MRI Chest Without IV Contrast. Chest MRI is not routinely used in the assessment of bronchiectasis complications or treatment response. A small prospective study used MRI with inhaled hyperpolarized ³He to assess ventilation in 15 patients with non-CF bronchiectasis and 15 age-matched controls, finding a greater percentage of ventilation defects in lobes with bronchiectasis than in healthy controls; ventilation defects improved in 8 of 14 patients who underwent respiratory therapy [57].

Radiography Chest. Radiography is often the initial chest imaging examination to evaluate acute conditions that may occur in patients with bronchiectasis, such as pneumonia and hemoptysis. Radiographs may also be used in follow-up of chronic lung conditions associated with bronchiectasis. The 2010 British Thoracic Society guidelines for non-CF bronchiectasis recommend a baseline chest radiograph in all patients with suspected bronchiectasis but recommend repeat radiographs only as clinically warranted [40].

Radiography Neck. There is no relevant literature to support the use of neck radiography in the evaluation of bronchiectasis complications or treatment response.

SUMMARY OF HIGHLIGHTS

■ **Variant 1:** In the initial imaging of suspected tracheal or bronchial stenosis, CT of the chest either without or with IV contrast is usually appropriate in evaluating both benign and neoplastic causes of airway stenosis; IV contrast may be helpful in depicting lesion enhancement and relationship to vessels. Radiography of the chest is usually appropriate as a first step to exclude other respiratory diseases that can cause symptoms overlapping those of airway stenosis. CT neck and chest with or without IV contrast may be appropriate, especially for diseases that can involve the subglottic trachea, such as diffuse tracheal diseases and suspected or known malignancies of the neck. CTA chest with IV contrast may be appropriate in cases of a suspected vascular abnormality as a cause of airway stenosis.

■ **Variant 2:** For pre- or posttreatment assessment of tracheal or bronchial stenosis, chest CT without or with IV contrast is usually appropriate and can be important in both planning surgical or bronchoscopic procedures and detection of posttreatment complications. Chest radiography is usually appropriate as an initial assessment of a wide range of potential posttreatment complications. CT neck and chest with or without IV contrast may be appropriate if assessment of the full length of the trachea is desired. FDG-PET/CT may be appropriate for pre- or posttreatment evaluation of airway neoplasms. There was disagreement as to whether neck CT without contrast alone may be appropriate in pre- or post-treatment assessment of tracheal or bronchial stenosis.

■ **Variant 3:** In the initial imaging evaluation of suspected tracheomalacia or bronchomalacia, CT chest without IV contrast with inspiratory and forced expiratory series is usually appropriate for detection of ECAC. CT neck and chest without IV contrast with inspiratory and expiratory series can be used to assess the full length of the trachea for expiratory collapse, and chest radiography can be used for exclusion of other diseases that can present with similar symptoms, but there was disagreement as to whether these examinations may be appropriate in the evaluation of suspected tracheomalacia or bronchomalacia.

■ **Variant 4:** For pre- or posttreatment assessment of tracheomalacia or bronchomalacia, CT chest without IV contrast is usually appropriate. CT chest with IV contrast or CTA chest with IV contrast may be appropriate for assessment of suspected posttreatment complications such as infection or bleeding. CT neck and chest without or with IV contrast may be appropriate for preprocedural planning or assessment of complications in the setting of neck involvement.

■ **Variant 5:** In the initial imaging evaluation of suspected bronchiectasis, chest radiography is usually appropriate for evaluation of associated conditions and exclusion of diseases that cause similar symptoms. CT chest without IV contrast is usually appropriate and provides information about the extent, severity, and distribution of bronchiectasis as well as evaluation of associated parenchymal disease. CTA chest with IV contrast may be appropriate for assessment of important vascular findings, such as dilated bronchial arteries and other systemic collateral vessels that can be sources of bleeding. MRI chest without IV contrast may be appropriate for evaluation of presence and extent of bronchiectasis but is inferior

to CT in evaluation of the lung parenchyma and is not widely used for this indication.

■ **Variant 6:** For assessment of complications of bronchiectasis, CT chest without IV contrast is usually appropriate and can detect changes in extent or severity of bronchiectasis and associated parenchymal disease. Radiography of the chest is usually appropriate as a first step in assessing thoracic diseases that can complicate bronchiectasis, such as infection, or in excluding other diseases that can cause worsening symptoms. CT chest with IV contrast may be appropriate in the setting of suspected acute infection and associated complications. CTA chest with IV contrast may be appropriate in cases of suspected bleeding as a cause of hemoptysis.

SUPPORTING DOCUMENTS

The evidence table, literature search, and appendix for this topic are available at <https://acsearch.acr.org/list>. The appendix includes the strength of evidence assessment and the final rating round tabulations for each recommendation.

For additional information on the Appropriateness Criteria methodology and other supporting documents go to www.acr.org/ac.

RELATIVE RADIATION LEVEL INFORMATION

Potential adverse health effects associated with radiation exposure are an important factor to consider when selecting the appropriate imaging procedure. Because there is a wide range of radiation exposures associated with different diagnostic procedures, a relative radiation level (RRL) indication has been included for each imaging examination. The RRLs are based on effective dose, which is a radiation dose quantity that is used to estimate population total radiation risk associated with an imaging procedure. Patients in the pediatric age group are at inherently higher risk from exposure, because of both organ sensitivity and longer life expectancy (relevant to the long latency that appears to accompany radiation exposure). For these reasons, the RRL dose estimate ranges for pediatric examinations are lower as compared with those specified for adults (see [Table 2](#)). Additional information regarding radiation dose assessment for imaging examinations can be found in the ACR Appropriateness Criteria® Radiation Dose Assessment Introduction document [58].

REFERENCES

1. Dunlap DG, Ravenel J, Sechrist J, Semaan R. Interventional therapies for central airways. *J Thorac Imaging* 2019;34:W49-59.
2. Little BP, Duong PT. Imaging of diseases of the large airways. *Radiol Clin North Am* 2016;54:1183-203.
3. McInnis MC, Weisbrod G, Schmidt H. Advanced technologies for imaging and visualization of the tracheobronchial tree: from computed tomography and MRI to virtual endoscopy. *Thorac Surg Clin* 2018;28:127-37.
4. Aslam A, De Luis Cardenas J, Morrison RJ, et al. Tracheobronchomalacia and excessive dynamic airway collapse: current concepts and future directions. *Radiographics* 2022;42:1012-27.
5. Mitropoulos A, Song WJ, Almaghlouth F, Kemp S, Polkey M, Hull JH. Detection and diagnosis of large airway collapse: a systematic review. *ERJ Open Res* 2021;7:00055-02021.
6. Bhatt SP, Terry NL, Nath H, et al. Association between expiratory central airway collapse and respiratory outcomes among smokers. *JAMA* 2016;315:498-505.
7. Tanabe N, Terada K, Shima H, et al. Expiratory central airway collapse and symptoms in smokers. *Respir Investig* 2021;59:522-9.
8. Bezuidenhout AF, Boisselle PM, Heidinger BH, et al. Longitudinal follow-up of patients with tracheobronchomalacia after undergoing tracheobronchoplasty: computed tomography findings and clinical correlation. *J Thorac Imaging* 2019;34:278-83.
9. Chalmers JD, Chang AB, Chotirmall SH, Dhar R, McShane PJ. Bronchiectasis. *Nat Rev Dis Primers* 2018;4:45.
10. Milliron B, Henry TS, Veeraraghavan S, Little BP. Bronchiectasis: mechanisms and imaging clues of associated common and uncommon diseases. *Radiographics* 2015;35:1011-30.
11. LoCicero J 3rd, Costello P, Campos CT, et al. Spiral CT with multiplanar and three-dimensional reconstructions accurately predicts tracheobronchial pathology. *Ann Thorac Surg* 1996;62:811-7.
12. Luo M, Duan C, Qiu J, Li W, Zhu D, Cai W. Diagnostic value of multidetector CT and its multiplanar reformation, volume rendering and virtual bronchoscopy postprocessing techniques for primary trachea and main bronchus tumors. *PLoS One* 2015;10:e0137329.
13. Taha MS, Mostafa BE, Fahmy M, Ghaffar MK, Ghany EA. Spiral CT virtual bronchoscopy with multiplanar reformatting in the evaluation of post-intubation tracheal stenosis: comparison between endoscopic, radiological and surgical findings. *Eur Arch Otorhinolaryngol* 2009;266:863-6.
14. Hernandez-Rojas D, Abia-Trujillo D, Rojas C, et al. Cinematic CT as a valuable protocol for severe ECAC. *Respirol Case Rep* 2022;10:e0884.
15. Wagnetz U, Roberts HC, Chung T, Patsios D, Chapman KR, Paul NS. Dynamic airway evaluation with volume CT: initial experience. *Can Assoc Radiol J* 2010;61:90-7.
16. Zhang J, Hasegawa I, Feller-Kopman D, Boisselle PM. 2003 AUR Memorial Award. Dynamic expiratory volumetric CT imaging of the central airways: comparison of standard-dose and low-dose techniques. *Acad Radiol* 2003;10:719-24.
17. Boisselle PM, O'Donnell CR, Bankier AA, et al. Tracheal collapsibility in healthy volunteers during forced expiration: assessment with multidetector CT. *Radiology* 2009;252:255-62.
18. Cohen SL, Ben-Levi E, Karp JB, et al. Ultralow dose dynamic expiratory computed tomography for evaluation of tracheomalacia. *J Comput Assist Tomogr* 2019;43:307-11.
19. Wang SC, Yin LK, Zhang Y, et al. CT diagnosis and prognosis prediction of tracheal adenoid cystic carcinoma. *Eur J Radiol* 2021;140:109746.
20. Finkelstein SE, Schrupp DS, Nguyen DM, Hewitt SM, Kunst TF, Summers RM. Comparative evaluation of super high-resolution CT scan and virtual bronchoscopy for the detection of tracheobronchial malignancies. *Chest* 2003;124:1834-40.
21. Koletsis EN, Kalogeropoulou C, Prodromaki E, et al. Tumoral and non-tumoral trachea stenoses: evaluation with three-dimensional CT and virtual bronchoscopy. *J Cardiothorac Surg* 2007;2:18.
22. Chen Q, Goo JM, Seo JB, Chung MJ, Lee YJ, Im JG. Evaluation of tracheobronchial diseases: comparison of different imaging techniques. *Korean J Radiol* 2000;1:135-41.
23. Sundarakumar DK, Bhalla AS, Sharma R, Hari S, Guleria R, Khilnani GC. Multidetector CT evaluation of central airways stenoses:

- comparison of virtual bronchoscopy, minimal-intensity projection, and multiplanar reformatted images. *Indian J Radiol Imaging* 2011;21:191-4.
24. Godoy MC, Saldana DA, Rao PP, et al. Multidetector CT evaluation of airway stents: what the radiologist should know. *Radiographics* 2014;34:1793-806.
25. Righini C, Aniwidyaningsih W, Ferretti G, et al. Computed tomography measurements for airway stent insertion in malignant airway obstruction. *J Bronchology Interv Pulmonol* 2010;17:22-8.
26. Xiong M, Zhang W, Wang D, Xu J. CT virtual bronchoscopy: imaging method and clinical application. *Chin Med J (Engl)* 2000;113:1022-5.
27. Wang SY, Wang SX, Liao JQ, Chen G. 18F-FDG PET/CT and contrast-enhanced CT of Primary malignant tracheal tumor. *Clin Nucl Med* 2016;41:595-605.
28. Shao D, Gao Q, Cheng Y, Du DY, Wang SY, Wang SX. The prognostic value of (18)F-fluorodeoxyglucose PET/CT in the initial assessment of primary tracheal malignant tumor: a retrospective study. *Korean J Radiol* 2021;22:425-34.
29. Baroni RH, Feller-Kopman D, Nishino M, et al. Tracheobronchomalacia: comparison between end-expiratory and dynamic expiratory CT for evaluation of central airway collapse. *Radiology* 2005;235:635-41.
30. Heussel CP, Hafner B, Lill J, Schreiber W, Thelen M, Kauczor HU. Paired inspiratory/expiratory spiral CT and continuous respiration cine CT in the diagnosis of tracheal instability. *Eur Radiol* 2001;11:982-9.
31. O'Donnell CR, Bankier AA, O'Donnell DH, Loring SH, Boiselle PM. Static end-expiratory and dynamic forced expiratory tracheal collapse in COPD. *Clin Radiol* 2014;69:357-62.
32. Heussel CP, Ley S, Biedermann A, et al. Respiratory luminal change of the pharynx and trachea in normal subjects and COPD patients: assessment by cine-MRI. *Eur Radiol* 2004;14:2188-97.
33. Ciet P, Boiselle PM, Heidinger B, et al. Cine MRI of tracheal dynamics in healthy volunteers and patients with tracheobronchomalacia. *AJR Am J Roentgenol* 2017;209:757-61.
34. Watase S, Sonoda A, Matsutani N, et al. Evaluation of intrathoracic tracheal narrowing in patients with obstructive ventilatory impairment using dynamic chest radiography: a preliminary study. *Eur J Radiol* 2020;129:109141.
35. Baroni RH, Ashiku S, Boiselle PM. Dynamic CT evaluation of the central airways in patients undergoing tracheoplasty for tracheobronchomalacia. *AJR Am J Roentgenol* 2005;184:1444-9.
36. Lee KS, Ashiku SK, Ernst A, et al. Comparison of expiratory CT airway abnormalities before and after tracheoplasty surgery for tracheobronchomalacia. *J Thorac Imaging* 2008;23:121-6.
37. Hansell DM, Bankier AA, MacMahon H, McLoud TC, Muller NL, Remy J. Fleischner Society: glossary of terms for thoracic imaging. *Radiology* 2008;246:697-722.
38. Cartier Y, Kavanagh PV, Johkoh T, Mason AC, Muller NL. Bronchiectasis: accuracy of high-resolution CT in the differentiation of specific diseases. *AJR Am J Roentgenol* 1999;173:47-52.
39. Lee PH, Carr DH, Rubens MB, Cole P, Hansell DM. Accuracy of CT in predicting the cause of bronchiectasis. *Clin Radiol* 1995;50:839-41.
40. Pasteur MC, Bilton D, Hill AT, British Thoracic Society Bronchiectasis non CFGG. British Thoracic Society guideline for non-CF bronchiectasis. *Thorax* 2010;65(Suppl 1):i1-58.
41. Reiff DB, Wells AU, Carr DH, Cole PJ, Hansell DM. CT findings in bronchiectasis: limited value in distinguishing between idiopathic and specific types. *AJR Am J Roentgenol* 1995;165:261-7.
42. Garcia B, Wilmskoetter J, Grady A, Mingora C, Dorman S, Flume P. Chest computed tomography features of nontuberculous mycobacterial pulmonary disease versus asymptomatic colonization: a cross-sectional cohort study. *J Thorac Imaging* 2022;37:140-5.
43. Meerburg JJ, Veerman GDM, Aliberti S, Tiddens H. Diagnosis and quantification of bronchiectasis using computed tomography or magnetic resonance imaging: a systematic review. *Respir Med* 2020;170:105954.
44. Chalmers JD, Goeminne P, Aliberti S, et al. The bronchiectasis severity index. An international derivation and validation study. *Am J Respir Crit Care Med* 2014;189:576-85.
45. Lynch DA, Newell J, Hale V, et al. Correlation of CT findings with clinical evaluations in 261 patients with symptomatic bronchiectasis. *AJR Am J Roentgenol* 1999;173:53-8.
46. Dimakou K, Triantafillidou C, Toumbis M, Tsikritsaki K, Malagari K, Bakakos P. Non CF-bronchiectasis: aetiological approach, clinical, radiological, microbiological and functional profile in 277 patients. *Respir Med* 2016;116:1-7.
47. Arslan S, Poyraz N, Ucar R, Yesildag M, Yesildag A, Caliskaner AZ. Magnetic resonance imaging may be a valuable radiation-free technique for lung pathologies in patients with primary immunodeficiency. *J Clin Immunol* 2016;36:66-72.
48. Chung JH, Huitt G, Yagihashi K, et al. Proton magnetic resonance imaging for initial assessment of isolated mycobacterium avium complex pneumonia. *Ann Am Thorac Soc* 2016;13:49-57.
49. Furuuchi K, Ito A, Hashimoto T, Kumagai S, Ishida T. Clinical significance of the radiological severity score in Mycobacterium avium complex lung disease patients. *Int J Tuberc Lung Dis* 2017;21:452-7.
50. Mehrian P, Farnia P, Karamad M. The association between computed tomography scan findings of pulmonary infection caused by atypical mycobacteria and bacillus count in sputum samples. *Int J Mycobacteriol* 2018;7:355-7.
51. Hwang JA, Kim S, Jo KW, Shim TS. Natural history of Mycobacterium avium complex lung disease in untreated patients with stable course. *Eur Respir J* 2017;49:1600537.
52. Park TY, Chong S, Jung JW, et al. Natural course of the nodular bronchiectatic form of Mycobacterium avium complex lung disease: long-term radiologic change without treatment. *PLoS One* 2017;12:e0185774.
53. Lee G, Kim HS, Lee KS, et al. Serial CT findings of nodular bronchiectatic Mycobacterium avium complex pulmonary disease with antibiotic treatment. *AJR Am J Roentgenol* 2013;201:764-72.
54. Asakura T, Yamada Y, Namkoong H, et al. Impact of cavity and infiltration on pulmonary function and health-related quality of life in pulmonary Mycobacterium avium complex disease: a 3-dimensional computed tomographic analysis. *Respir Med* 2017;126:9-16.
55. Kwak N, Lee JH, Kim HJ, Kim SA, Yim JJ. New-onset nontuberculous mycobacterial pulmonary disease in bronchiectasis: tracking the clinical and radiographic changes. *BMC Pulm Med* 2020;20:293.
56. Park J, Yoon SH, Kim JY, Gu KM, Kwak N, Yim JJ. Radiographic severity and treatment outcome of Mycobacterium abscessus complex pulmonary disease. *Respir Med* 2021;187:106549.
57. Svenningsen S, Guo F, McCormack DG, Parraga G. Nonspecific fibrosis bronchiectasis: regional abnormalities and response to airway clearance therapy using pulmonary functional magnetic resonance imaging. *Acad Radiol* 2017;24:4-12.
58. American College of Radiology. ACR Appropriateness Criteria® Radiation dose assessment introduction. Available at: <https://www.acr.org/-/media/ACR/Files/Appropriateness-Criteria/RadiationDoseAssessmentIntro.pdf>. Accessed March 29, 2024.