

**American College of Radiology
ACR Appropriateness Criteria®
Chronic Dyspnea-Noncardiovascular Origin**

Variant 1: Chronic dyspnea. Unclear etiology. Initial imaging.

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

Variant 2: Chronic dyspnea. Suspected chronic obstructive pulmonary disease (COPD). Initial imaging.

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

Variant 3: Chronic dyspnea. Suspected central airways disease. Initial imaging.

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	⊗⊗⊗
MRI chest without and with IV contrast	May Be Appropriate	○
MRI chest without IV contrast	May Be Appropriate	○
CT chest without and with IV contrast	Usually Not Appropriate	⊗⊗⊗
FDG-PET/CT skull base to mid-thigh	Usually Not Appropriate	⊗⊗⊗⊗
US chest	Usually Not Appropriate	○

Variant 4: Chronic dyspnea. Suspected interstitial lung disease. Initial imaging.

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

Variant 5: Chronic dyspnea. Suspected disease of the pleura or chest wall. 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	☼☼☼
MRI chest without and with IV contrast	May Be Appropriate (Disagreement)	○
MRI chest without IV contrast	May Be Appropriate	○
US chest	May Be Appropriate (Disagreement)	○
FDG-PET/CT skull base to mid-thigh	Usually Not Appropriate	☼☼☼☼
CT chest without and with IV contrast	Usually Not Appropriate	☼☼☼

Variant 6: Chronic dyspnea. Suspected diaphragm dysfunction. Initial imaging.

Procedure	Appropriateness Category	Relative Radiation Level
Radiography chest	Usually Appropriate	☼
Fluoroscopy chest	Usually Appropriate	☼☼☼
MRI chest without and with IV contrast	May Be Appropriate	○
MRI chest without IV contrast	May Be Appropriate	○
US chest	May Be Appropriate	○
CT chest with IV contrast	Usually Not Appropriate	☼☼☼
CT chest without and with IV contrast	Usually Not Appropriate	☼☼☼
CT chest without IV contrast	Usually Not Appropriate	☼☼☼

CHRONIC DYSPNEA-NONCARDIOVASCULAR ORIGIN

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Summary of Literature Review

Introduction/Background

Dyspnea is the subjective experience of breathing discomfort [1], often described as a feeling of breathlessness, or shortness of breath. The perception of dyspnea derives from the interactions of physiological, psychological, environmental, and social factors that may provoke various physiologic and behavioral responses. Clinical history and physical examination may provide insight into the cause or causes of dyspnea; however, laboratory and ancillary tests are also often necessary.

Chronic dyspnea implies shortness of breath of >1 month duration [2]. The differential diagnosis encompasses a wide variety of pathologies [3], including cardiovascular, pulmonary, gastrointestinal, neuromuscular, systemic, and psychogenic disorders. A multifactorial etiology is reported in up to a third of patients [4], with cardiovascular and pulmonary etiologies being the most common. Chronic dyspnea can be associated with a wide variety of disorders involving the airways, airspace, interstitium, pulmonary vessels, mediastinum and hila, pleura, diaphragm, and chest wall. Asthma, bronchitis, chronic obstructive pulmonary disease (COPD), and interstitial lung disease (ILD) are frequently implicated. See the ACR Appropriateness Criteria[®] topic on “[Dyspnea-Suspected Cardiac Origin](#)” [5] and the ACR Appropriateness Criteria[®] topic on “[Suspected Pulmonary Hypertension](#)” [6] for further details.

Overview of Imaging Modalities

Radiography Chest

The workup of chronic dyspnea is influenced by its severity, the rate of worsening, and the presence or absence of risk factors and other symptoms. The initial evaluation is aimed at determining whether the cause is related to cardiovascular disease, pulmonary disease, a combination of both, or neither. A chest radiograph will typically be performed in the initial workup. The results of the chest radiograph can help guide, and sometimes eliminate the need for, further investigation. Using an algorithmic approach, the combination of chest radiograph and laboratory evaluation may result in a specific diagnosis in one-third of cases [7].

CT Chest

CT has an important role in the imaging evaluation of chronic dyspnea. It is useful when a radiographic abnormality requires further characterization or clinical findings necessitate additional imaging despite a normal radiograph [8,9]. For most routine applications, intravenous (IV) contrast is not needed, although it may be added when vascular abnormalities are in the differential diagnosis. CT protocols should be tailored to meet individual needs and may be determined based on radiographs and clinical features. For dyspnea, thin collimation of the lung parenchyma is essential. Most modern scanners allow this without additional data to be acquired. Adjuncts, such as expiratory images, prone images, and dynamic imaging of the airways, may be applied in certain clinical situations; therefore, knowledge of the suspected diagnosis is essential for planning the CT scan.

MRI Chest

MRI does not currently have a significant role in the evaluation of chronic dyspnea that is not of cardiovascular origin. However, MRI may play a role in the workup of congenital anomalies and diseases of the

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cardiopulmonary axis where both pulmonary imaging and cardiac imaging are desired in a single examination, and in the tissue characterization and assessment of extent of thoracic lesions.

FDG-PET/CT Skull Base to Mid-Thigh

Functional information from PET using the tracer fluorine-18-2-fluoro-2-deoxy-D-glucose (FDG)/CT can complement morphologic information derived from chest radiographs and CT. Attempts have been made to determine the efficacy of FDG-PET/CT in the behavior of inflammatory cells, extent of active lung disease, and response to therapy [10]. To date, evidence is limited to small series and has not been subjected to use in pharmacologic trials.

US Chest

Transthoracic ultrasound (US) imaging can be used for assessment of the lung periphery and pleura. Major advantages include portability, ease of use, and real-time imaging capability. US can target abnormalities and complement other imaging studies. It is particularly suited to bedside evaluation. Examples of uses in chronic dyspnea include the assessment of pleural and chest wall pathology, peripheral lung abnormalities, evaluation of diaphragmatic function, and guidance of interventional procedures.

Discussion of Procedures by Variant

Variant 1: Chronic dyspnea. Unclear etiology. Initial imaging.

Radiography Chest

The chest radiograph should generally be the initial imaging study in chronic dyspnea. Pratter et al [11] reported that it added sufficient information to justify its routine use. In conjunction with cardiomyopathy, two-thirds of cases of chronic dyspnea in a pulmonary clinic were caused by asthma, COPD, and ILD. Pratter et al [7] later employed a prospective algorithmic approach to chronic dyspnea that used the chest radiograph as part of a Tier I evaluation. Karnani et al [2] advocated an algorithm that used the history and physical examination to guide appropriate testing, with the chest radiograph a component of a Level 1 diagnostic workup. Wahls [3] addressed the importance of the chest radiograph in the initial workup of chronic dyspnea in patients both with and without other physical examination findings.

A chest radiograph might reveal a wide variety of abnormalities in chronic dyspnea that may guide further imaging choices as outlined in subsequent variants. Examples include COPD, ILD, central airways disease, and pleural, chest wall, and diaphragmatic pathology.

CT Chest

In cases where the chest radiograph is normal or does not provide a direct answer, CT can be beneficial for documenting abnormalities not identified on a chest radiograph and guiding further workup [8,12]. In the Multi-Ethnic Study of Atherosclerosis lung study, CT imaging for parenchymal disease was considered to be the most informative imaging test [13].

MRI Chest

MRI has not been evaluated in a systematic manner for the assessment of patients with nonspecific chronic dyspnea, although it may have a role in specific clinical situations.

US Chest

Transthoracic US has good test characteristics for peripheral thoracic abnormalities, although it does not provide the comprehensive evaluation that CT does in the setting of an unspecified cause.

FDG-PET/CT Skull Base to Mid-Thigh

FDG-PET/CT has not been evaluated in a systematic manner for the assessment of patients with nonspecific chronic dyspnea, although it may have a role in specific clinical situations.

Variant 2: Chronic dyspnea. Suspected chronic obstructive pulmonary disease (COPD). Initial imaging.

Radiography Chest

In COPD, a radiograph can help exclude alternative diagnoses and evaluate for comorbidities and complications [14]. Wallace et al [15] reported that 14% of chest radiographs ordered during COPD evaluation detected potentially treatable causes of dyspnea other than COPD and lung cancer and that 84% of radiographs assisted management.

CT Chest

CT has greater sensitivity and specificity than a chest radiograph in determining the type, extent, and distribution of emphysema and bronchial wall abnormalities [16]. CT is able to identify early changes of COPD in asymptomatic and spirometrically normal smokers [17]. It has shown that visual assessments of emphysema and airway disease are accurate and reproducible [18]. In addition, quantitative CT-derived parameters correlate with pulmonary function tests and can be used as imaging biomarkers to follow disease progression [19-23]. Findings have been shown to correlate with patient-reported measures [24-26] and to predict health status in COPD [27]. CT-based phenotypes have prognostic value in predicting future hospitalization, symptomatic decline, and mortality [28,29]. Expiratory CT has been reported to reflect airflow limitation and correlates well with levels of dyspnea [30].

MRI Chest

Numerous MRI techniques are available to evaluate COPD, including hyperpolarized helium, T1 oxygen-enhanced mapping, and equilibrium signal mapping [31-33]. While predominately the subject of research, small studies have shown good correlation with CT-derived measures and provide a rationale for the use of MRI when quantitative imaging measures are needed.

US Chest

US may have a role in defining pleural or diaphragmatic complications related to COPD, but there is no supporting evidence for its use as a diagnostic technique for this condition.

FDG-PET/CT Skull Base to Mid-Thigh

There are no primary data to support the use of FDG-PET/CT to diagnose or manage COPD.

Variant 3: Chronic dyspnea. Suspected central airways disease. Initial imaging.

Radiography Chest

Chest radiographs have the potential to identify conditions of the trachea, with accuracy dependent on the condition to be identified. Compared to CT, radiographs have an accuracy of 89% [34]. It should be noted that radiographic findings may be normal or nonspecific. In a single-institution retrospective study of tracheal neoplasms, <50% were directly detectable by a chest radiograph [35].

CT Chest

Examples of airway conditions that may result in chronic dyspnea and can be accurately diagnosed by CT include stenoses, tumors, and end-expiratory airway collapse/tracheobronchomalacia, with strong correlations when compared with bronchoscopy [36,37]. For the last condition, expiratory images are required for diagnosis. Both dynamic airway imaging and static forced expiratory imaging are able to accurately characterize airway collapse when compared with bronchoscopy [38,39]. It has been shown that the degree of expiratory collapse is greater on dynamic studies compared to static forced expiratory images, although the clinical importance of this observation remains unclear [39,40]. Forced expiratory measurements show good reproducibility in healthy volunteers [41]. Volume acquisition of the airways allows for the production of 2-D and 3-D reformations that can better delineate the extent of abnormalities, while perspective volume rendering (virtual bronchoscopy) may be helpful in preprocedural planning.

MRI Chest

There are limited data supporting the use of MRI for the central airways in adult populations [42,43]. Some data supporting the use of MRI in pediatric populations [44,45] may be applicable in adults.

FDG-PET/CT Skull Base to Mid-Thigh

FDG-PET/CT has a supplemental role in the staging of tracheal neoplasms; however, there are no data to support its use in other tracheal conditions.

US Chest

One small study has shown that measurements obtained from US imaging of the extrathoracic trachea correlate well with MRI [46]; however, a transthoracic US technique is limited by its inability to evaluate the entire tracheobronchial tree.

Variant 4: Chronic dyspnea. Suspected interstitial lung disease. Initial imaging.

Radiography Chest

The chest radiograph may be abnormal in diffuse ILD; however, studies documenting the sensitivity of chest radiographs predate the widespread use of CT [47]. A normal chest radiograph in the setting of suspected ILD does not exclude the possibility of clinically important ILD. In subjects with diseases that predispose them to ILD (eg, connective tissue disease), it is reasonable to consider CT rather than radiography as the primary screening modality.

CT Chest

CT is currently the preferred imaging method for evaluating ILD [48]. CT protocols should be tailored to the clinical setting and may include expiratory or prone imaging. Good correlation has been reported between extent of disease on CT and severity of dyspnea [49-53]. CT findings are often sufficient to permit either a limited differential or confident diagnosis; the latter occurs particularly in the diagnosis of usual interstitial pneumonia [54-57], although the diagnostic yield improves with multidisciplinary discussion [58,59]. There is moderate agreement across individuals in the rating of honeycomb change [60]. The presence and extent of honeycomb change and other imaging features of ILD may serve as important prognostic variables [61,62].

MRI Chest

MRI does not currently have an established clinical role in the evaluation of ILD, although small studies have shown good concordance with CT [63-65]. In general, MRI does not yet display the same level of parenchymal detail that is available with CT. A specific advantage of MRI may exist when a single examination is desired for the evaluation of both ILD and its effect on the cardiovascular system [66].

FDG-PET/CT Skull Base to Mid-Thigh

FDG-PET/CT may have a secondary role in ILD evaluation. It can be used as a marker of disease extent and severity in sarcoidosis [67], reveal inflammatory activity before morphological changes are demonstrated on CT [68], and assist in follow-up and the monitoring of treatment response [10]. Some studies show that the degree of FDG activity correlates with severity and prognosis in ILD [69-71].

US Chest

US has been evaluated as a potential ILD screening tool in high-risk populations. In scleroderma, US was concordant with CT in 83% of patients and demonstrated high sensitivity [72]. It is being used in some centers to detect chronic ILD [73,74] and is emerging as a monitoring tool [75].

Variant 5: Chronic dyspnea. Suspected disease of the pleura or chest wall. Initial imaging.

Radiography Chest

Pleural effusion is often diagnosed by a chest radiograph, and volume can reasonably be estimated [76]. A radiograph is somewhat limited in its ability to determine the exact location of an abnormality, whether parenchymal, pleural, or extrapleural. A chest radiograph may reveal structural abnormalities of the sternum, ribs, and thoracic spine that may predispose toward dyspnea.

CT Chest

CT is superior to radiographs in detecting and characterizing pleural disease, differentiating it from parenchymal and chest wall disease, and determining the extent of involvement [77]. CT is somewhat limited in its ability to differentiate causes of pleural effusion, although the presence of pleural thickening or enhancement may help document complex exudative and malignant effusions [78,79].

MRI Chest

MRI may provide improved characterization and assessment of the extent of pleural and chest wall abnormalities compared to CT. MRI can help distinguish components of complex fluid collections, including septations [80], and is thought to be slightly better at distinguishing benign from malignant pleural thickening [81]. Improved soft-tissue contrast allows for better demonstration of soft-tissue relationships, which can facilitate the assessment of invasion and neurovascular encasement. Small studies have shown that MRI is capable of providing diagnostic images to guide surgical chest wall reconstruction [82]. There is extensive supportive literature in pediatric populations surrounding the detection and management of pectus excavatum.

FDG-PET/CT Skull Base to Mid-Thigh

FDG-PET/CT remains a secondary test that may be used in the staging of mesothelioma and pleural metastatic disease.

US Chest

US can complement the imaging evaluation of several abnormalities. US has an established role in pleural effusion, including detection, differentiation from lung disease, characterization, and guidance of intervention. US may be more efficacious than chest radiography and CT at detecting internal septations in complex pleural effusions [83]. Pleural thickening, plaques, and masses may be identifiable on US, although US is not recommended in their workup. US is advantageous in the bedside diagnosis of pneumothorax and is most often used in acute assessment [84].

Variant 6: Chronic dyspnea. Suspected diaphragm dysfunction. Initial imaging.

Radiography Chest

A static chest radiograph is useful to assess the relative position of the diaphragm and its effect on lung volumes and can provide clues to diaphragm paralysis compared to a fluoroscopic reference standard [85].

Fluoroscopy Chest

With fluoroscopic visualization, more accurate assessment of diaphragmatic motion can be made [86,87].

CT Chest

While CT can document the position of the diaphragm with multiplanar imaging and in theory can provide dynamic information, there are no data to support its use in the analysis of diaphragmatic dysfunction.

MRI Chest

Although not widely practiced, cine dynamic MRI sequences allow for the direct visualization of diaphragm motion [88]. This can result in comprehensive analysis of both the diaphragm and chest wall muscle movement in neuromuscular diseases [89].

US Chest

US findings have been found to be concordant with fluoroscopic imaging of diaphragm motion, with reproducible results [90]. Diaphragmatic excursion amplitude, thickness, and contraction can be evaluated, and paralysis may be identified as paradoxical movement during respiration [91]. There is high sensitivity and specificity for the diagnosis of neuromuscular disorders of the diaphragm [92-95]. The extent of diaphragm motion in various conditions, including neuromuscular diseases, COPD, and ILD, correlates with respiratory symptoms and lung function [96-100].

Summary of Recommendations

- **Variant 1:** For patients with chronic dyspnea of unclear etiology, it is usually appropriate to initially evaluate with chest radiography, which may reveal a wide variety of abnormalities and guide further imaging decisions.
- **Variant 2:** The appropriate initial imaging study for patients with chronic dyspnea with suspected COPD is usually a chest radiograph, which can evaluate for comorbidities, complications, and alternative diagnoses.
- **Variant 3:** A chest radiograph is usually appropriate for the initial imaging of patients with chronic dyspnea and suspected central airways disease. Alternatively, CT without IV contrast is also usually appropriate, particularly for the detection of airway collapse, stenosis, or tumor.
- **Variant 4:** CT without IV contrast is usually appropriate for the initial imaging of patients with chronic dyspnea and suspected ILD, especially if the patient has a disease that predisposes to ILD. Alternatively, initial imaging with chest radiography is usually appropriate, although a normal chest radiograph does not exclude clinically important ILD.
- **Variant 5:** For patients with chronic dyspnea and suspected pleural or chest wall disease, initial imaging with chest radiography is usually appropriate. Alternatively, initial imaging by CT without or with IV contrast is usually appropriate; CT is superior in distinguishing, characterizing, and assessing the extent of pleural and chest wall abnormalities.
- **Variant 6:** It is usually appropriate to initially image patients with chronic dyspnea and suspected diaphragm dysfunction by chest radiography, which can assess diaphragm position and provide clues to the presence of paralysis. Alternatively, initial imaging by fluoroscopy is usually appropriate and provides a more accurate assessment of diaphragm motion.

Summary of Evidence

Of the 101 references cited in the *ACR Appropriateness Criteria® Chronic Dyspnea-Noncardiovascular Origin* document, all of them are categorized as diagnostic references including 2 well-designed studies, 30 good-quality studies, and 41 quality studies that may have design limitations. There are 28 references that may not be useful as primary evidence.

The 101 references cited in the *ACR Appropriateness Criteria® Chronic Dyspnea-Noncardiovascular Origin* document were published from 1978 to 2017.

Although there are references that report on studies with design limitations, 32 well-designed or good-quality studies provide good evidence.

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.

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 below). Additional information regarding radiation dose assessment for imaging examinations can be found in the *ACR Appropriateness Criteria® Radiation Dose Assessment Introduction* document [101].

Relative Radiation Level Designations		
Relative Radiation Level*	Adult Effective Dose Estimate Range	Pediatric Effective Dose Estimate Range
○	0 mSv	0 mSv
⊛	<0.1 mSv	<0.03 mSv
⊛⊛	0.1-1 mSv	0.03-0.3 mSv
⊛⊛⊛	1-10 mSv	0.3-3 mSv
⊛⊛⊛⊛	10-30 mSv	3-10 mSv
⊛⊛⊛⊛⊛	30-100 mSv	10-30 mSv

*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”.

Supporting Documents

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

References

1. Parshall MB, Schwartzstein RM, Adams L, et al. An official American Thoracic Society statement: update on the mechanisms, assessment, and management of dyspnea. *Am J Respir Crit Care Med* 2012;185:435-52.
2. Karnani NG, Reisfield GM, Wilson GR. Evaluation of chronic dyspnea. *Am Fam Physician* 2005;71:1529-37.
3. Wahls SA. Causes and evaluation of chronic dyspnea. *Am Fam Physician* 2012;86:173-82.
4. Michelson E, Hollrah S. Evaluation of the patient with shortness of breath: an evidence based approach. *Emerg Med Clin North Am* 1999;17:221-37, x.
5. Vogel-Claussen J, Elshafee ASM, Kirsch J, et al. ACR Appropriateness Criteria(R) Dyspnea-Suspected Cardiac Origin. *J Am Coll Radiol* 2017;14:S127-S37.
6. Sirajuddin A, Donnelly EF, Crabtree TP, et al. ACR Appropriateness Criteria(R) Suspected Pulmonary Hypertension. *J Am Coll Radiol* 2017;14:S350-S61.
7. Pratter MR, Abouzgheib W, Akers S, Kass J, Bartter T. An algorithmic approach to chronic dyspnea. *Respir Med* 2011;105:1014-21.
8. Klein JS, Gamsu G, Webb WR, Golden JA, Muller NL. High-resolution CT diagnosis of emphysema in symptomatic patients with normal chest radiographs and isolated low diffusing capacity. *Radiology* 1992;182:817-21.
9. Zompatori M, Bna C, Poletti V, et al. Diagnostic imaging of diffuse infiltrative disease of the lung. *Respiration* 2004;71:4-19.
10. Capitanio S, Nordin AJ, Noraini AR, Rossetti C. PET/CT in nononcological lung diseases: current applications and future perspectives. *Eur Respir Rev* 2016;25:247-58.
11. Pratter MR, Curley FJ, Dubois J, Irwin RS. Cause and evaluation of chronic dyspnea in a pulmonary disease clinic. *Arch Intern Med* 1989;149:2277-82.
12. Grenier P, Chevret S, Beigelman C, Brauner MW, Chastang C, Valeyre D. Chronic diffuse infiltrative lung disease: determination of the diagnostic value of clinical data, chest radiography, and CT and Bayesian analysis. *Radiology* 1994;191:383-90.
13. Oelsner EC, Lima JA, Kawut SM, et al. Noninvasive tests for the diagnostic evaluation of dyspnea among outpatients: the Multi-Ethnic Study of Atherosclerosis lung study. *Am J Med* 2015;128:171-80 e5.
14. Cleverley JR, Muller NL. Advances in radiologic assessment of chronic obstructive pulmonary disease. *Clin Chest Med* 2000;21:653-63.
15. Wallace GM, Winter JH, Winter JE, Taylor A, Taylor TW, Cameron RC. Chest X-rays in COPD screening: are they worthwhile? *Respir Med* 2009;103:1862-5.

16. Lynch DA, Austin JH, Hogg JC, et al. CT-Definable Subtypes of Chronic Obstructive Pulmonary Disease: A Statement of the Fleischner Society. *Radiology* 2015;277:192-205.
17. Regan EA, Lynch DA, Curran-Everett D, et al. Clinical and Radiologic Disease in Smokers With Normal Spirometry. *JAMA Intern Med* 2015;175:1539-49.
18. Kim SS, Seo JB, Lee HY, et al. Chronic obstructive pulmonary disease: lobe-based visual assessment of volumetric CT by Using standard images--comparison with quantitative CT and pulmonary function test in the COPDGene study. *Radiology* 2013;266:626-35.
19. Boes JL, Hoff BA, Bule M, et al. Parametric response mapping monitors temporal changes on lung CT scans in the subpopulations and intermediate outcome measures in COPD Study (SPIROMICS). *Acad Radiol* 2015;22:186-94.
20. Gu S, Leader J, Zheng B, et al. Direct assessment of lung function in COPD using CT densitometric measures. *Physiol Meas* 2014;35:833-45.
21. Lee YK, Oh YM, Lee JH, et al. Quantitative assessment of emphysema, air trapping, and airway thickening on computed tomography. *Lung* 2008;186:157-65.
22. Wang G, Wang L, Ma Z, Zhang C, Deng K. Quantitative emphysema assessment of pulmonary function impairment by computed tomography in chronic obstructive pulmonary disease. *J Comput Assist Tomogr* 2015;39:171-5.
23. Yahaba M, Kawata N, Iesato K, et al. The effects of emphysema on airway disease: correlations between multi-detector CT and pulmonary function tests in smokers. *Eur J Radiol* 2014;83:1022-28.
24. Lee JS, Lee SM, Seo JB, et al. Clinical utility of computed tomographic lung volumes in patients with chronic obstructive pulmonary disease. *Respiration* 2014;87:196-203.
25. Martinez CH, Chen YH, Westgate PM, et al. Relationship between quantitative CT metrics and health status and BODE in chronic obstructive pulmonary disease. *Thorax* 2012;67:399-406.
26. Nambu A, Zach J, Schroeder J, et al. Quantitative computed tomography measurements to evaluate airway disease in chronic obstructive pulmonary disease: Relationship to physiological measurements, clinical index and visual assessment of airway disease. *Eur J Radiol* 2016;85:2144-51.
27. Han MK, Bartholmai B, Liu LX, et al. Clinical significance of radiologic characterizations in COPD. *COPD* 2009;6:459-67.
28. Van Tho N, Ogawa E, Trang le TH, et al. A mixed phenotype of airway wall thickening and emphysema is associated with dyspnea and hospitalization for chronic obstructive pulmonary disease. *Ann Am Thorac Soc* 2015;12:988-96.
29. Zulueta JJ, Wisnivesky JP, Henschke CI, et al. Emphysema scores predict death from COPD and lung cancer. *Chest* 2012;141:1216-23.
30. Camiciottoli G, Bartolucci M, Maluccio NM, et al. Spirometrically gated high-resolution CT findings in COPD: lung attenuation vs lung function and dyspnea severity. *Chest* 2006;129:558-64.
31. Capaldi DP, Zha N, Guo F, et al. Pulmonary Imaging Biomarkers of Gas Trapping and Emphysema in COPD: (3)He MR Imaging and CT Parametric Response Maps. *Radiology* 2016;279:597-608.
32. Ohno Y, Koyama H, Yoshikawa T, et al. Comparison of capability of dynamic O(2)-enhanced MRI and quantitative thin-section MDCT to assess COPD in smokers. *Eur J Radiol* 2012;81:1068-75.
33. Zhang WJ, Hubbard Cristinacce PL, Bondesson E, et al. MR Quantitative Equilibrium Signal Mapping: A Reliable Alternative to CT in the Assessment of Emphysema in Patients with Chronic Obstructive Pulmonary Disease. *Radiology* 2015;275:579-88.
34. Ciccarese F, Poerio A, Stagni S, et al. Saber-sheath trachea as a marker of severe airflow obstruction in chronic obstructive pulmonary disease. *Radiol Med* 2014;119:90-6.
35. Stevic R, Milenkovic B, Stojsic J, Pesut D, Ercegovic M, Jovanovic D. Clinical and radiological manifestations of primary tracheobronchial tumours: a single centre experience. *Ann Acad Med Singapore* 2012;41:205-11.
36. Heidinger BH, Occhipinti M, Eisenberg RL, Bankier AA. Imaging of Large Airways Disorders. *AJR Am J Roentgenol* 2015;205:41-56.
37. Sun M, Ernst A, Boiselle PM. MDCT of the central airways: comparison with bronchoscopy in the evaluation of complications of endotracheal and tracheostomy tubes. *J Thorac Imaging* 2007;22:136-42.
38. Lee KS, Sun MRM, Ernst A, Feller-Kopman D, Majid A, Boiselle PM. Comparison of Dynamic Expiratory CT With Bronchoscopy for Diagnosing Airway Malacia: A Pilot Evaluation. *Chest* 2007;131:758-64.

39. 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.
40. Ferretti GR, Jankowski A, Perrin MA, et al. Multi-detector CT evaluation in patients suspected of tracheobronchomalacia: comparison of end-expiratory with dynamic expiratory volumetric acquisitions. *Eur J Radiol* 2008;68:340-6.
41. Boiselle PM, O'Donnell CR, Loring SH, Bankier AA. Reproducibility of forced expiratory tracheal collapse: assessment with MDCT in healthy volunteers. *Acad Radiol* 2010;17:1186-9.
42. Klink T, Holle J, Laudien M, et al. Magnetic resonance imaging in patients with granulomatosis with polyangiitis (Wegener's) and subglottic stenosis. *MAGMA* 2013;26:281-90.
43. 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.
44. Liszewski MC, Ciet P, Sodhi KS, Lee EY. Updates on MRI Evaluation of Pediatric Large Airways. *AJR Am J Roentgenol* 2017;208:971-81.
45. Puderbach M, Eichinger M, Gahr J, et al. Proton MRI appearance of cystic fibrosis: comparison to CT. *Eur Radiol* 2007;17:716-24.
46. Or DY, Karmakar MK, Lam GC, Hui JW, Li JW, Chen PP. Multiplanar 3D ultrasound imaging to assess the anatomy of the upper airway and measure the subglottic and tracheal diameters in adults. *Br J Radiol* 2013;86:20130253.
47. Epler GR, McCloud TC, Gaensler EA, Mikus JP, Carrington CB. Normal chest roentgenograms in chronic diffuse infiltrative lung disease. *N Engl J Med* 1978;298:934-9.
48. Walsh SL, Hansell DM. High-resolution CT of interstitial lung disease: a continuous evolution. *Semin Respir Crit Care Med* 2014;35:129-44.
49. Grydeland TB, Dirksen A, Coxson HO, et al. Quantitative computed tomography measures of emphysema and airway wall thickness are related to respiratory symptoms. *Am J Respir Crit Care Med* 2010;181:353-9.
50. Muller NL, Mawson JB, Mathieson JR, Abboud R, Ostrow DN, Champion P. Sarcoidosis: correlation of extent of disease at CT with clinical, functional, and radiographic findings. *Radiology* 1989;171:613-8.
51. Papiris SA, Daniil ZD, Malagari K, et al. The Medical Research Council dyspnea scale in the estimation of disease severity in idiopathic pulmonary fibrosis. *Respir Med* 2005;99:755-61.
52. Staples CA, Muller NL, Vedal S, Abboud R, Ostrow D, Miller RR. Usual interstitial pneumonia: correlation of CT with clinical, functional, and radiologic findings. *Radiology* 1987;162:377-81.
53. Terriff BA, Kwan SY, Chan-Yeung MM, Muller NL. Fibrosing alveolitis: chest radiography and CT as predictors of clinical and functional impairment at follow-up in 26 patients. *Radiology* 1992;184:445-9.
54. Chung JH, Chawla A, Peljto AL, et al. CT scan findings of probable usual interstitial pneumonitis have a high predictive value for histologic usual interstitial pneumonitis. *Chest* 2015;147:450-59.
55. Elicker B, Pereira CA, Webb R, Leslie KO. High-resolution computed tomography patterns of diffuse interstitial lung disease with clinical and pathological correlation. *J Bras Pneumol* 2008;34:715-44.
56. Sundaram B, Gross BH, Martinez FJ, et al. Accuracy of high-resolution CT in the diagnosis of diffuse lung disease: effect of predominance and distribution of findings. *AJR Am J Roentgenol* 2008;191:1032-9.
57. Verrastro CG, Antunes VB, Jasinowodolinski D, D'Ippolito G, Meirelles GS. High-Resolution Computed Tomography in the Diagnosis of Diffuse Parenchymal Lung Diseases: Is it Possible to Improve Radiologist's Performance? *J Comput Assist Tomogr* 2016;40:248-55.
58. Flaherty KR, King TE, Jr., Raghu G, et al. Idiopathic interstitial pneumonia: what is the effect of a multidisciplinary approach to diagnosis? *Am J Respir Crit Care Med* 2004;170:904-10.
59. Thomeer M, Demedts M, Behr J, et al. Multidisciplinary interobserver agreement in the diagnosis of idiopathic pulmonary fibrosis. *Eur Respir J* 2008;31:585-91.
60. Watadani T, Sakai F, Johkoh T, et al. Interobserver variability in the CT assessment of honeycombing in the lungs. *Radiology* 2013;266:936-44.
61. Hozumi H, Nakamura Y, Johkoh T, et al. Nonspecific interstitial pneumonia: prognostic significance of high-resolution computed tomography in 59 patients. *J Comput Assist Tomogr* 2011;35:583-9.
62. Hwang JH, Misumi S, Curran-Everett D, Brown KK, Sahin H, Lynch DA. Longitudinal follow-up of fibrosing interstitial pneumonia: relationship between physiologic testing, computed tomography changes, and survival rate. *J Thorac Imaging* 2011;26:209-17.

63. Ohno Y, Nishio M, Koyama H, et al. Pulmonary MR imaging with ultra-short TEs: utility for disease severity assessment of connective tissue disease patients. *Eur J Radiol* 2013;82:1359-65.
64. Ohno Y, Nishio M, Koyama H, et al. Oxygen-enhanced MRI for patients with connective tissue diseases: comparison with thin-section CT of capability for pulmonary functional and disease severity assessment. *Eur J Radiol* 2014;83:391-7.
65. Yi CA, Lee KS, Han J, Chung MP, Chung MJ, Shin KM. 3-T MRI for differentiating inflammation- and fibrosis-predominant lesions of usual and nonspecific interstitial pneumonia: comparison study with pathologic correlation. *AJR Am J Roentgenol* 2008;190:878-85.
66. Kato S, Sekine A, Kusakawa Y, et al. Prognostic value of cardiovascular magnetic resonance derived right ventricular function in patients with interstitial lung disease. *J Cardiovasc Magn Reson* 2015;17:10.
67. Keijsers RG, Grutters JC, Thomeer M, et al. Imaging the inflammatory activity of sarcoidosis: sensitivity and inter observer agreement of (67)Ga imaging and (18)F-FDG PET. *Q J Nucl Med Mol Imaging* 2011;55:66-71.
68. Mostard RL, van Kroonenburgh MJ, Drent M. The role of the PET scan in the management of sarcoidosis. *Curr Opin Pulm Med* 2013;19:538-44.
69. Groves AM, Win T, Sreaton NJ, et al. Idiopathic pulmonary fibrosis and diffuse parenchymal lung disease: implications from initial experience with 18F-FDG PET/CT. *J Nucl Med* 2009;50:538-45.
70. Jacquelin V, Mekinian A, Brillet PY, et al. FDG-PET/CT in the prediction of pulmonary function improvement in nonspecific interstitial pneumonia. A Pilot Study. *Eur J Radiol* 2016;85:2200-05.
71. Nobashi T, Kubo T, Nakamoto Y, et al. 18F-FDG Uptake in Less Affected Lung Field Provides Prognostic Stratification in Patients with Interstitial Lung Disease. *J Nucl Med* 2016;57:1899-904.
72. Barskova T, Gargani L, Guiducci S, et al. Lung ultrasound for the screening of interstitial lung disease in very early systemic sclerosis. *Ann Rheum Dis* 2013;72:390-5.
73. Hasan AA, Makhlof HA. B-lines: Transthoracic chest ultrasound signs useful in assessment of interstitial lung diseases. *Ann Thorac Med* 2014;9:99-103.
74. Sener Cömert S, Çaglayan B, Dogan C, et al. Ultrasound in the assessment of interstitial lung diseases: Correlation with high-resolution computed tomography and lung functions. *European Respiratory Journal* 2015;46:PA3841.
75. Gigante A, Rossi Fanelli F, Lucci S, et al. Lung ultrasound in systemic sclerosis: correlation with high-resolution computed tomography, pulmonary function tests and clinical variables of disease. *Intern Emerg Med* 2016;11:213-7.
76. Blackmore CC, Black WC, Dallas RV, Crow HC. Pleural fluid volume estimation: a chest radiograph prediction rule. *Acad Radiol* 1996;3:103-9.
77. Kuhlman JE, Singha NK. Complex disease of the pleural space: radiographic and CT evaluation. *Radiographics* 1997;17:63-79.
78. Hallifax RJ, Haris M, Corcoran JP, et al. Role of CT in assessing pleural malignancy prior to thoracoscopy. *Thorax* 2015;70:192-3.
79. Tsujimoto N, Saraya T, Light RW, et al. A Simple Method for Differentiating Complicated Parapneumonic Effusion/Empyema from Parapneumonic Effusion Using the Split Pleura Sign and the Amount of Pleural Effusion on Thoracic CT. *PLoS One* 2015;10:e0130141.
80. McCloud TC, Flower CD. Imaging the pleura: sonography, CT, and MR imaging. *AJR Am J Roentgenol* 1991;156:1145-53.
81. Inan N, Sarisoy HT, Cam I, Sakci Z, Arslan A. Diffusion-weighted Magnetic Resonance Imaging in the Differential Diagnosis of Benign and Metastatic Malignant Pleural Thickening. *J Thorac Imaging* 2016;31:37-42.
82. Rinaldi P, Parapatt GK, Giuliani M, et al. Chest and breast MRI: the added value of a fast imaging for a new diagnostic approach in the planning of augmentation surgery in patients with thoracic asymmetries. *Eur Rev Med Pharmacol Sci* 2015;19:2359-67.
83. Svigals PZ, Chopra A, Ravenel JG, Nietert PJ, Huggins JT. The accuracy of pleural ultrasonography in diagnosing complicated parapneumonic pleural effusions. *Thorax* 2017;72:94-95.
84. Tsai T-H, Jerng J-S, Yang P-C. Clinical Applications of Transthoracic Ultrasound in Chest Medicine. *Journal of Medical Ultrasound* 2008;16:7-25.
85. Verhey PT, Gosselin MV, Primack SL, Kraemer AC. Differentiating diaphragmatic paralysis and eventration. *Acad Radiol* 2007;14:420-5.

86. Nason LK, Walker CM, McNeeley MF, Burivong W, Fligner CL, Godwin JD. Imaging of the diaphragm: anatomy and function. *Radiographics* 2012;32:E51-70.
87. Saltiel RV, Grams ST, Pedrini A, Paulin E. High reliability of measure of diaphragmatic mobility by radiographic method in healthy individuals. *Braz J Phys Ther* 2013;17:128-36.
88. Kiryu S, Loring SH, Mori Y, Rofsky NM, Hatabu H, Takahashi M. Quantitative analysis of the velocity and synchronicity of diaphragmatic motion: dynamic MRI in different postures. *Magn Reson Imaging* 2006;24:1325-32.
89. Mogalle K, Perez-Rovira A, Ciet P, et al. Quantification of Diaphragm Mechanics in Pompe Disease Using Dynamic 3D MRI. *PLoS One* 2016;11:e0158912.
90. Noh DK, Lee JJ, You JH. Diaphragm breathing movement measurement using ultrasound and radiographic imaging: a concurrent validity. *Biomed Mater Eng* 2014;24:947-52.
91. Sarwal A, Walker FO, Cartwright MS. Neuromuscular ultrasound for evaluation of the diaphragm. *Muscle Nerve* 2013;47:319-29.
92. Boon AJ, Sekiguchi H, Harper CJ, et al. Sensitivity and specificity of diagnostic ultrasound in the diagnosis of phrenic neuropathy. *Neurology* 2014;83:1264-70.
93. Fantini R, Mandrioli J, Zona S, et al. Ultrasound assessment of diaphragmatic function in patients with amyotrophic lateral sclerosis. *Respirology* 2016;21:932-8.
94. Hiwatani Y, Sakata M, Miwa H. Ultrasonography of the diaphragm in amyotrophic lateral sclerosis: clinical significance in assessment of respiratory functions. *Amyotroph Lateral Scler Frontotemporal Degener* 2013;14:127-31.
95. O'Gorman CM, O'Brien T G, Boon AJ. Utility Of diaphragm ultrasound in myopathy. *Muscle Nerve* 2017;55:427-29.
96. Baria MR, Shahgholi L, Sorenson EJ, et al. B-mode ultrasound assessment of diaphragm structure and function in patients with COPD. *Chest* 2014;146:680-85.
97. Carrie C, Bonnardel E, Vally R, Revel P, Marthan R. Vital Capacity Impairment due to Neuromuscular Disease and its Correlation with Diaphragmatic Ultrasound: A Preliminary Study. *Ultrasound Med Biol* 2016;42:143-9.
98. Noda Y, Sekiguchi K, Kohara N, Kanda F, Toda T. Ultrasonographic diaphragm thickness correlates with compound muscle action potential amplitude and forced vital capacity. *Muscle Nerve* 2016;53:522-7.
99. Pinto S, Alves P, Pimentel B, Swash M, de Carvalho M. Ultrasound for assessment of diaphragm in ALS. *Clin Neurophysiol* 2016;127:892-97.
100. Santana PV, Prina E, Albuquerque AL, Carvalho CR, Caruso P. Identifying decreased diaphragmatic mobility and diaphragm thickening in interstitial lung disease: the utility of ultrasound imaging. *J Bras Pneumol* 2016;42:88-94.
101. 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 September 30, 2018.

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.