

**American College of Radiology
ACR Appropriateness Criteria®
Occupational Lung Diseases**

Variant: 1 Occupational exposure, screening, and surveillance of lung disease. Initial imaging.

Procedure	Appropriateness Category	Relative Radiation Level
Radiography chest	Usually Appropriate	⊕
CT chest without IV contrast	May Be Appropriate	⊕⊕⊕
MRI chest without and with IV contrast	Usually Not Appropriate	O
MRI chest without IV contrast	Usually Not Appropriate	O
CT chest with IV contrast	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: 2 Occupational exposure, suspected interstitial lung disease. Initial imaging.

Procedure	Appropriateness Category	Relative Radiation Level
Radiography chest	Usually Appropriate	⊕
CT chest without IV contrast	Usually Appropriate	⊕⊕⊕
MRI chest without and with IV contrast	Usually Not Appropriate	O
MRI chest without IV contrast	Usually Not Appropriate	O
CT chest with IV contrast	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 Occupational exposure, suspected interstitial lung disease based on radiography. Next imaging study.

Procedure	Appropriateness Category	Relative Radiation Level
CT chest without IV contrast	Usually Appropriate	⊕⊕⊕
Image-guided transthoracic needle biopsy	Usually Not Appropriate	Varies
MRI chest without and with IV contrast	Usually Not Appropriate	O
MRI chest without IV contrast	Usually Not Appropriate	O
CT chest with IV contrast	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: 4 Occupational exposure, suspected airway disease. Initial imaging.

Procedure	Appropriateness Category	Relative Radiation Level
Radiography chest	Usually Appropriate	⊕
CT chest without IV contrast	Usually Appropriate	⊕⊕⊕
MRI chest without and with IV contrast	Usually Not Appropriate	O
MRI chest without IV contrast	Usually Not Appropriate	O
CT chest with IV contrast	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 Confirmed occupational lung disease, suspected thoracic neoplasm.

Procedure	Appropriateness Category	Relative Radiation Level
Image-guided transthoracic needle biopsy	Usually Appropriate	Varies
CT chest with IV contrast	Usually Appropriate	⊕⊕⊕
Radiography chest	May Be Appropriate	⊕
MRI chest without and with IV contrast	May Be Appropriate	O
MRI chest without IV contrast	May Be Appropriate	O
CT chest without IV contrast	May Be Appropriate	⊕⊕⊕
FDG-PET/CT skull base to mid-thigh	May Be Appropriate	⊕⊕⊕⊕⊕
CT chest without and with IV contrast	Usually Not Appropriate	⊕⊕⊕

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Summary of Literature Review

Introduction/Background

Inhalational exposures in the workplace that result in airway, parenchymal, or pleural pathology constitute an “occupational lung disease.” Typical occupational exposures include inhalation of inorganic particles such as silica dust, coal dust, and asbestos fibers resulting in pneumoconioses; organic dust inhalation resulting in hypersensitivity pneumonitis; and other various inhalants resulting in airway or lung injury. Updating the definition of occupational lung disease aligns more closely with current definitions by pulmonary, occupational, and environmental medicine societies [1-3].

Despite well-known risks and mitigation efforts, occupational lung diseases such as the pneumoconioses continue to arise for a variety of reasons [4-11]. Medical imaging continues to play a critical role in the diagnosis and management of occupational lung disease, with increasing use of chest CT, particularly at reduced dose [12-14]. Various biomarkers in conjunction with medical imaging are proving to further refine assessment [15-20]. As in other areas of diffuse lung disease, multidisciplinary assessment consistently demonstrates improved characterization of occupational lung disease [21-28].

Special Imaging Considerations

Imaging of emerging occupational lung diseases deserves special consideration. Imaging and pathologic manifestations may not be known in the setting of a new and unique exposure, potentially requiring a broader diagnostic evaluation than the variants discussed below [6,29-38].

Discussion of Procedures by Variant

Variant 1: Occupational exposure, screening, and surveillance of lung disease. Initial

imaging.

Variant 1: Occupational exposure, screening, and surveillance of lung disease. Initial imaging.

A. Radiography Chest

Driven by the International Labor Organization classification scheme for screening and surveillance of pneumoconioses, chest radiography remains an important imaging modality in the arena of occupational lung disease. Epidemiologic studies using radiographs to screen United States coal miners continue to demonstrate developing coal workers pneumoconiosis [9,11,39,40]. Screening and surveillance of various occupations with chest radiographs reveal ongoing and new lung disease risks [7,8,41,42]. Additionally, chest radiographs have demonstrated correlation with physiologic testing [43]. In 2011, the International Labor Organization criteria for radiograph acquisition have expanded to include digital radiography with flat-panel detector viewing [44]. More recent studies continue to support the equivalence of analog radiography and digital radiography [40,45-47].

Variant 1: Occupational exposure, screening, and surveillance of lung disease. Initial imaging.

B. CT Chest

Although no studies have implemented a population-based CT screening and surveillance program specifically for occupational lung disease to examine morbidity or mortality benefit, several recent studies have used reduced-dose CT to demonstrate adequate detection of parenchymal changes in at-risk workers. In a prospective study of 55 patients with a 15-year asbestos exposure history, screening ultra-low-dose chest CT was compared with standard acquisition chest CT, demonstrating 91% sensitivity and 100% specificity for asbestos-associated primary endpoint findings [12]. Retrospective studies utilizing lung cancer screening examinations have also revealed potential benefit. For instance, Carrillo et al [48] found 44% of patients with an asbestos exposure history had associated pulmonary parenchymal abnormalities on low-dose CT performed for lung cancer screening. The International Classification of High-Resolution Computed Tomography for Occupational and Environmental Respiratory Diseases aims to standardize high-resolution CT (HRCT) findings for occupational screening [49]. CT with intravenous (IV) contrast serves no purpose in the setting of occupational lung disease screening and surveillance.

Variant 1: Occupational exposure, screening, and surveillance of lung disease. Initial imaging.

C. MRI Chest

Though there is evidence that shows that proton MRI may be useful in the setting of interstitial lung disease (ILD) and pulmonary fibrosis [50-53], there is no direct evidence to support the use of MRI as an initial imaging technique in population-based screening and surveillance of occupational lung disease.

Variant 1: Occupational exposure, screening, and surveillance of lung disease. Initial imaging.

D. FDG-PET/CT Skull Base to Mid-Thigh

There is no relevant literature to support the use of fluorine-18-2-fluoro-2-deoxy-D-glucose (FDG)-PET/CT as an initial imaging technique in population-based screening and surveillance of occupational lung disease.

Variant 2: Occupational exposure, suspected interstitial lung disease. Initial imaging.

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A. Radiography Chest

The chest radiograph and CT are complementary in the initial workup of suspected occupational lung

disease [21,24,54,55]. When patients with occupational exposures present with respiratory symptoms, chest radiography serves as the primary function of excluding alternative diagnoses, such as infectious pneumonia or pulmonary edema, with HRCT findings offering the best characterization of lung disease.

Variant 2: Occupational exposure, suspected interstitial lung disease. Initial imaging.

A. CT Chest

The primary imaging modality for symptomatic occupational lung disease is chest HRCT that often provides a definitive diagnosis, obviating the need for surgical biopsy. Ongoing studies continue to support the increased sensitivity and specificity of HRCT over chest radiography for changes related to occupational lung disease [26,43,56-58], although the level of radiologist expertise can affect interpretation [59]. HRCT proves central in the imaging of classic and emerging pneumoconioses [6,34,60-64], as well as differentiating occupational lung disease from other ILDs [65,66]. New HRCT findings are revealing additional imaging characteristics important to the diagnosis of occupational lung disease [67-70]. A negative chest CT also proves useful in excluding disease [71]. The International Classification of High-Resolution Computed Tomography for Occupational and Environmental Respiratory Diseases recently demonstrated correlation with physiologic testing [72]. Finally, CT imaging findings can provide prognostic value [73]. CT with IV contrast serves no purpose in the setting of suspected ILD.

Variant 2: Occupational exposure, suspected interstitial lung disease. Initial imaging.

C. MRI Chest

There is limited research supporting the use of MRI in occupational lung disease, none of which supports the use of MRI as the initial imaging.

Variant 2: Occupational exposure, suspected interstitial lung disease. Initial imaging.

D. FDG-PET/CT Skull Base to Mid-Thigh

There is no relevant literature to support the use of FDG-PET/CT in the initial imaging evaluation of suspected occupation-associated ILD.

Variant 3: Occupational exposure, suspected interstitial lung disease based on radiography.

Next imaging study.

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Next imaging study.

A. CT Chest

Chest radiography performed for screening, surveillance, or diagnostic reasons may reveal findings characteristic of occupational lung disease or nonspecific findings in the setting of reported occupational exposure [43,56]. When ILD is suspected on radiographs, chest HRCT again plays the central role in imaging diagnosis, not only further characterizing true lung disease but also increasing specificity by identifying false-positives [57,74]. As noted above, the use of chest CT to diagnose occupation-related ILD may avoid the need for lung biopsy, differentiate occupational lung disease from other diffuse lung diseases [66,73], and identify emerging occupational lung diseases [34,60-63]. CT findings in occupational lung disease may correlate with physiologic testing [72] and assist in determining prognosis [73]. CT with IV contrast serves no purpose in the setting of suspected ILD. However, IV contrast can be helpful in identifying nonpulmonary manifestations of occupational exposure.

Variant 3: Occupational exposure, suspected interstitial lung disease based on radiography.

Next imaging study.

B. MRI Chest

Select fast MRI sequences have approached the image quality of CT in characterizing progressive massive

fibrosis in the setting of pneumoconiosis [75]. A few recent studies have evaluated MRI for identifying ILD to include the use of 3T MRI with and without IV contrast in the setting of pulmonary fibrosis [51,53] and 1.5T MRI in systemic sclerosis [52], suggesting feasibility for differentiating normal lung from ILD. However, MRI has not been specifically studied for imaging of suspected occupation-associated ILD based on radiography.

Variant 3: Occupational exposure, suspected interstitial lung disease based on radiography.

Next imaging study.

C. 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 population-based screening and surveillance of occupational lung disease.

Variant 3: Occupational exposure, suspected interstitial lung disease based on radiography.

Next imaging study.

D. Image-Guided Transthoracic Needle Biopsy

There is no relevant literature to support the use of image-guided transthoracic needle biopsy for the evaluation of the diagnosis of ILD based on radiography.

Variant 4: Occupational exposure, suspected airway disease. Initial imaging.

Variant 4: Occupational exposure, suspected airway disease. Initial imaging.

A. Radiography Chest

Similar to suspected ILD, chest radiography serves a complementary role to chest HRCT in the evaluation of suspected airway disease, although airway findings, if present, are nonspecific on chest radiography [21,24,54,55]. Chest radiography primarily excludes alternative or complicating diagnoses, such as infectious pneumonia or pulmonary edema, with HRCT providing the best imaging characterization of airway disease.

Variant 4: Occupational exposure, suspected airway disease. Initial imaging.

B. CT Chest

Hypersensitivity pneumonitis typically presents with a combination of pneumonitis and small airway obstruction, producing characteristic findings on chest HRCT with expiratory imaging [76,77]. New and changing occupational exposures causing hypersensitivity pneumonitis are continually described, highlighting the importance of high clinical suspicion and evaluation with HRCT [33,78,79]. Imaging features of hypersensitivity pneumonitis on HRCT also provide predictive information regarding disease behavior [68,80-90] and drive treatment decisions [91].

Certain occupational inhalational exposures, such as diacetyl acetate and carbon dust, may lead to more isolated airway disease, such as constrictive bronchiolitis, bronchial anthracofibrosis, and occupational asthma. Various occupations, such as flavoring microwave popcorn, processing coffee, and serving on military deployment to Iraq/Afghanistan, can result in constrictive bronchiolitis [29-31] evident on HRCT with expiratory imaging [92]. Of note, a few studies over time have demonstrated the importance of tissue biopsy in the setting of negative HRCT but clinically suspected occupational small airway disease [30,93]. In large airway disease, CT may assist in certain diagnoses, such as isolated bronchial anthracofibrosis [35,93,94], although medical imaging has limited value in occupational asthma outside of diagnosing alternative disease. CT with IV contrast serves no purpose in the setting of suspected occupational airway disease.

Variant 4: Occupational exposure, suspected airway disease. Initial imaging.

C. MRI Chest

No specific studies have examined the use of MRI in the setting of occupation-associated airway disease. Although substantial literature supports research and clinical use of MRI for the study of other large and small airway diseases, such as chronic obstructive airway disease, asthma, lung transplant, and cystic fibrosis. [95-100].

Variant 4: Occupational exposure, suspected airway disease. Initial imaging.

D. FDG-PET/CT Skull Base to Mid-Thigh

There is no relevant literature to support the use of FDG-PET/CT in the initial imaging evaluation of suspected occupation-associated airway lung disease.

Variant 5: Confirmed occupational lung disease, suspected thoracic neoplasm.

Variant 5: Confirmed occupational lung disease, suspected thoracic neoplasm.

A. CT Chest

Several occupational exposures increase the risk for thoracic malignancies, the most common being mesothelioma and primary lung carcinoma. The association of malignancy with asbestos exposure is well known, but other occupational lung diseases also demonstrate increased rates of lung cancer [101,102]. Because of this increased risk, evaluation of occupational lung disease requires an increased level of suspicion for malignancy and may warrant the use of advanced imaging. Characteristic CT imaging features may help differentiate occupational lung disease from thoracic neoplasm, with additional CT imaging benefits to include potential for cancer screening, risk stratification, and guidance for biopsy [103-111]. As further discussed and supported in the ACR Appropriateness Criteria® topic on "[Noninvasive Clinical Staging of Primary Lung Cancer](#)" [112], CT chest with IV contrast is recommended for initial imaging because of improved characterization of direct extrapulmonary tumor invasion and thoracic metastatic disease. Additionally, contrast enhancement increases sensitivity of primary or metastatic pleural malignancies [111]. CT chest without IV contrast is "Usually Appropriate" for initial evaluation of suspected neoplasm but generally in the context of additional complementary imaging [112]. Chest CT has known limitations for diagnosis of malignancy, often requiring alternative imaging assessment or diagnostic testing [109,111].

Variant 5: Confirmed occupational lung disease, suspected thoracic neoplasm.

B. MRI Chest

MRI has been shown in some small studies to be useful in the setting of occupational lung disease and suspected malignancy. For instance, it can be helpful in differentiating progressive massive fibrosis from malignancy [113], characterizing known pleural mesothelioma [114,115], and distinguishing benign from malignant lymphadenopathy [116]. MRI chest with and without contrast is recommended over MRI chest without contrast for increased detection and characterization of pleural malignancy, particularly for mesothelioma diagnosis [117].

Variant 5: Confirmed occupational lung disease, suspected thoracic neoplasm.

C. FDG-PET/CT Skull Base to Mid-Thigh

Recent studies reveal mixed potential benefit of PET/CT for the evaluation of potential malignancy complicating occupational lung disease. PET/CT poorly differentiates benign from malignant changes in progressive massive fibrosis [118,119] but can provide benefit in the diagnosis of pleural and lung malignancies in asbestos exposure [120-122]. The decision between CT surveillance, PET/CT, and lesion biopsy is generally situational and should be determined in the setting of multidisciplinary discussions.

Variant 5: Confirmed occupational lung disease, suspected thoracic neoplasm.

D. Image-Guided Transthoracic Needle Biopsy

Transthoracic needle biopsy is a well-established diagnostic test in the workup of suspected thoracic neoplasm, with diagnostic accuracy ranging from 77% to 93% [123-125]. Selection of image-guided transthoracic needle biopsy over bronchoscopic biopsy or surgical excision biopsy depends on a number of variables, such as location, size, and distant disease. Research studies examining detection of malignancy by imaging often use transthoracic needle biopsy as a gold standard [104,113,118], although no literature currently addresses the effect of diffuse occupational lung disease on the sensitivity or specificity of transthoracic needle biopsy.

Variant 5: Confirmed occupational lung disease, suspected thoracic neoplasm.

E. Radiography Chest

Chest radiographs play a complementary role to additional imaging in the evaluation of suspected thoracic neoplasm but alone prove inadequate for the detection of pulmonary malignancy in occupational lung disease [126].

Summary of Recommendations

- **Variant 1:** Radiography of the chest is usually appropriate for the initial imaging of patients who undergo screening and surveillance for lung disease when occupational exposure is present.
- **Variant 2:** Chest CT without IV contrast and radiographs of the chest are usually appropriate for the initial imaging of patients when occupational exposure is present with suspected ILD. These procedures are complementary (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.)
- **Variant 3:** Chest CT without IV contrast is usually appropriate as the next imaging study for patients when occupational exposure is present with suspected ILD based on radiography.
- **Variant 4:** Chest CT without IV contrast and radiographs of the chest are usually appropriate for the initial imaging of patients when occupational exposure is present with suspected airway disease. These procedures are complementary (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.)
- **Variant 5:** Chest CT with IV contrast and image-guided transthoracic needle biopsy are usually appropriate for patients with confirmed occupational lung disease and suspected thoracic neoplasm. These procedures are complementary (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.)

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, please go to the ACR website at <https://www.acr.org/Clinical-Resources/Clinical-Tools-and-Reference/Appropriateness-Criteria>.

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.

Relative Radiation Level Designations

Relative Radiation Level*	Adult Effective Dose Estimate Range	Pediatric Effective Dose Estimate Range
0	0 mSv	0 mSv
● (radioactive symbol)	<0.1 mSv	<0.03 mSv
● (radioactive symbol) ● (radioactive symbol)	0.1-1 mSv	0.03-0.3 mSv
● (radioactive symbol) ● (radioactive symbol) ● (radioactive symbol)	1-10 mSv	0.3-3 mSv
● (radioactive symbol) ● (radioactive symbol) ● (radioactive symbol) ● (radioactive symbol)	10-30 mSv	3-10 mSv
● (radioactive symbol)	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 (e.g., region of the body exposed to ionizing radiation, the imaging guidance that is used). The RRLs for these examinations are designated as "Varies."

References

1. Harber P, Redlich CA, Henneberger PK. Work-Related Lung Diseases. *Am J Respir Crit Care Med.* 193(2):P3-4, 2016 Jan 15.
2. Tarlo SM, Altman KW, Oppenheimer J, et al. Occupational and Environmental Contributions to Chronic Cough in Adults: Chest Expert Panel Report. [Review]. *Chest.* 150(4):894-907, 2016 Oct.
3. Gibson GJ, Loddenkemper R, Lundback B, Sibille Y. Respiratory health and disease in Europe: the new European Lung White Book. *Eur Respir J.* 42(3):559-63, 2013 Sep.
4. Gruber JM, Harris G, Almberg KS, Rose CS, Petsonk EL, Cohen RA. Increasing Severity of Pneumoconiosis Among Younger Former US Coal Miners Working Exclusively Under Modern Dust-Control Regulations. *J Occup Environ Med.* 59(6):e105-e111, 2017 Jun.
5. Reynolds LE, Blackley DJ, Laney AS, Halldin CN. Respiratory morbidity among U.S. coal miners in states outside of central Appalachia. *Am J Ind Med.* 60(6):513-517, 2017 Jun.
6. Grubstein A, Shtraichman O, Fireman E, Bachar GN, Noach-Ophir N, Kramer MR. Radiological Evaluation of Artificial Stone Silicosis Outbreak: Emphasizing Findings in Lung Transplant Recipients. *J Comput Assist Tomogr.* 40(6):923-927, 2016 Nov/Dec.
7. Dumavibhat N, Matsui T, Hoshino E, et al. Radiographic progression of silicosis among Japanese tunnel workers in Kochi. *J Occup Health.* 55(3):142-8, 2013.
8. Akgun M, Araz O, Ucar EY, et al. Silicosis Appears Inevitable Among Former Denim Sandblasters: A 4-Year Follow-up Study. *Chest.* 148(3):647-654, 2015 Sep.
9. Blackley DJ, Halldin CN, Wang ML, Laney AS. Small mine size is associated with lung function abnormality and pneumoconiosis among underground coal miners in Kentucky, Virginia and West Virginia. *Occup Environ Med.* 71(10):690-4, 2014 Oct.
10. Alici NS, Cimrin A, Coskun Beyan A. Pneumoconiosis in different sectors and their differences in Turkey. *Tuberk. Toraks.* 64(4):275-282, 2016 Dec.
11. Wade WA, Petsonk EL, Young B, Mogri I. Severe occupational pneumoconiosis among West Virginian coal miners: one hundred thirty-eight cases of progressive massive fibrosis compensated between 2000 and 2009. *Chest.* 139(6):1458-1462, 2011 Jun.
12. Schaal M, Severac F, Labani A, Jeung MY, Roy C, Ohana M. Diagnostic Performance of Ultra-Low-Dose Computed Tomography for Detecting Asbestos-Related Pleuropulmonary Diseases: Prospective Study in a Screening Setting. *PLoS ONE.* 11(12):e0168979, 2016.
13. Murray CP, Wong PM, Teh J, et al. Ultra low dose CT screen-detected non-malignant incidental findings in the Western Australian Asbestos Review Programme. *Respirology.* 21(8):1419-1424, 2016 11.
14. Macia-Suarez D, Sanchez-Rodriguez E, Lopez-Calvino B, Diego C, Pombar M. Low-voltage chest CT: another way to reduce the radiation dose in asbestos-exposed patients. *Clin Radiol.* 72(9):797.e1-797.e10, 2017 Sep.
15. Ates I, Yucesoy B, Yucel A, Suzen SH, Karakas Y, Karakaya A. Possible effect of gene polymorphisms on the release of TNFalpha and IL1 cytokines in coal workers' pneumoconiosis. *Exp Toxicol Pathol.* 63(1-2):175-9, 2011 Jan.

16. Braz NF, Carneiro AP, Amorim MR, et al. Association between inflammatory biomarkers in plasma, radiological severity, and duration of exposure in patients with silicosis. *J Occup Environ Med.* 56(5):493-7, 2014 May.
17. Liu SJ, Wang P, Jiao J, Han L, Lu YM. Differential gene expression associated with inflammation in peripheral blood cells of patients with pneumoconiosis. *J Occup Health.* 58(4):373-80, 2016 Jul 22.
18. Okamoto T, Fujii M, Furusawa H, Tsuchiya K, Miyazaki Y, Inase N. The usefulness of KL-6 and SP-D for the diagnosis and management of chronic hypersensitivity pneumonitis. *Respir Med.* 109(12):1576-81, 2015 Dec.
19. Yu B, Yang X, Li F, Wu C, Wang W, Ding W. Significance of Foxp3+CD4+ regulatory T cells in the peripheral blood of Uygur patients in the acute and chronic phases of pigeon breeder's lung. *Bosn. j. basic med. sci..* 17(1):17-22, 2017 Feb 21.
20. Lee JS, Shin JH, Lee KM, et al. Serum levels of TGF-beta1 and MCP-1 as biomarkers for progressive coal workers' pneumoconiosis in retired coal workers: a three-year follow-up study. *Ind Health.* 52(2):129-36, 2014.
21. Berk S, Dogan DO, Gumus C, Akkurt I. Relationship between radiological (X-ray/HRCT), spirometric and clinical findings in dental technicians' pneumoconiosis. *The clinical respiratory journal.* 10(1):67-73, 2016 Jan.
22. Chiba S, Tsuchiya K, Akashi T, et al. Chronic Hypersensitivity Pneumonitis With a Usual Interstitial Pneumonia-Like Pattern: Correlation Between Histopathologic and Clinical Findings. *Chest.* 149(6):1473-81, 2016 06.
23. Fernandez Perez ER, Swigris JJ, Forssen AV, et al. Identifying an inciting antigen is associated with improved survival in patients with chronic hypersensitivity pneumonitis. *Chest.* 144(5):1644-1651, 2013 Nov.
24. Fujimoto N, Gemba K, Aoe K, et al. Clinical Investigation of Benign Asbestos Pleural Effusion. *Pulm Med.* 2015:416179, 2015.
25. Kumar R, Singh M. Bird fancier's lung: clinical-radiological presentation in 15 cases. *Pneumonol Alergol Pol.* 83(1):39-44, 2015.
26. Martin SG, Kronek LP, Valeyre D, et al. High-resolution computed tomography to differentiate chronic diffuse interstitial lung diseases with predominant ground-glass pattern using logical analysis of data. *Eur Radiol.* 2010 Jun;20(6):1297-310.
27. Morell F, Roger A, Reyes L, Cruz MJ, Murio C, Munoz X. Bird fancier's lung: a series of 86 patients. *Medicine (Baltimore).* 87(2):110-30, 2008 Mar.
28. Petsonk EL, Stansbury RC, Beeckman-Wagner LA, Long JL, Wang ML. Small Airway Dysfunction and Abnormal Exercise Responses. A Study in Coal Miners. *Annals of the American Thoracic Society.* 13(7):1076-80, 2016 07.
29. Centers for Disease Control and Prevention (CDC).. Obliterative bronchiolitis in workers in a coffee-processing facility - Texas, 2008-2012. *MMWR Morb Mortal Wkly Rep.* 62(16):305-7, 2013 Apr 26.
30. King MS, Eisenberg R, Newman JH, et al. Constrictive bronchiolitis in soldiers returning from Iraq and Afghanistan.[Erratum appears in *N Engl J Med.* 2011 Nov 3;365(18):1749]. *N Engl J Med.* 365(3):222-30, 2011 Jul 21.

31. Kreiss K, Gomaa A, Kullman G, Fedan K, Simoes EJ, Enright PL. Clinical bronchiolitis obliterans in workers at a microwave-popcorn plant. *N Engl J Med.* 347(5):330-8, 2002 Aug 01.
32. Verma H, Nicholson AG, Kerr KM, et al. Alveolar proteinosis with hypersensitivity pneumonitis: a new clinical phenotype. *Respirology.* 15(8):1197-202, 2010 Nov.
33. Sharma BB, Singh S, Singh V. Hypersensitivity pneumonitis: the dug-well lung. *Allergy Asthma Proc.* 34(6):e59-64, 2013 Nov-Dec.
34. Pereira Faria H, de Souza Veiga A, Coutinho Teixeira L, et al. Talcosis in soapstone artisans: high-resolution CT findings in 12 patients. *Clinical Radiology.* 69(3):e136-9, 2014 Mar.
35. Kahkouee S, Pourghorban R, Bitarafan M, Najafizadeh K, Makki SS. Imaging Findings of Isolated Bronchial Anthracofibrosis: A Computed Tomography Analysis of Patients With Bronchoscopic and Histologic Confirmation. *Arch Bronconeumol.* 51(7):322-7, 2015 Jul.
36. Lai PS, Hang JQ, Zhang FY, et al. Imaging Phenotype of Occupational Endotoxin-Related Lung Function Decline. *Environ Health Perspect.* 124(9):1436-42, 2016 09.
37. Kramer MR, Blanc PD, Fireman E, et al. Artificial stone silicosis [corrected]: disease resurgence among artificial stone workers.[Erratum appears in Chest. 2012 Oct;142(4):1080]. *Chest.* 142(2):419-424, 2012 Aug.
38. Hoy RF, Baird T, Hammerschlag G, et al. Artificial stone-associated silicosis: a rapidly emerging occupational lung disease. *Occup Environ Med.* 75(1):3-5, 2018 Jan.
39. Laney AS, Blackley DJ, Halldin CN. Radiographic disease progression in contemporary US coal miners with progressive massive fibrosis. *Occup Environ Med.* 74(7):517-520, 2017 Jul.
40. Halldin CN, Petsonk EL, Laney AS. Validation of the international labour office digitized standard images for recognition and classification of radiographs of pneumoconiosis. *Acad Radiol.* 21(3):305-11, 2014 Mar.
41. Dogan DO, Berk S, Gumus C, Ozdemir AK, Akkurt I. A longitudinal study on lung disease in dental technicians: what has changed after seven years?. *Int J Occup Med Environ Health.* 26(5):693-701, 2013 Oct.
42. Tsao YC, Liu SH, Tzeng IS, Hsieh TH, Chen JY, Luo JJ. Do sanitary ceramic workers have a worse presentation of chest radiographs or pulmonary function tests than other ceramic workers?. *J Formos Med Assoc.* 116(3):139-144, 2017 Mar.
43. Miller A, Warshaw R, Nezamis J. Diffusing capacity and forced vital capacity in 5,003 asbestos-exposed workers: relationships to interstitial fibrosis (ILO profusion score) and pleural thickening. *Am J Ind Med.* 2013 Dec;56(12):1383-93.
44. International Labour Office. Guidelines for the use of the ILO international classification of radiographs of pneumoconioses. Revised edition 2011. ed. Geneva: International Labour Office; 2011.
45. Lee WJ, Choi BS. Reliability and validity of soft copy images based on flat-panel detector in pneumoconiosis classification: comparison with the analog radiographs. *Acad Radiol.* 20(6):746-51, 2013 Jun.
46. Sen A, Lee SY, Gillespie BW, et al. Comparing film and digital radiographs for reliability of pneumoconiosis classifications: a modeling approach. *Acad Radiol.* 17(4):511-9, 2010 Apr.

47. Laney AS, Petsonk EL, Attfield MD. Intramodality and intermodality comparisons of storage phosphor computed radiography and conventional film-screen radiography in the recognition of small pneumoconiotic opacities. *Chest*. 2011 Dec;140(6):S0012-3692(11)60655-7.

48. Carrillo MC, Alturkistany S, Roberts H, et al. Low-dose computed tomography (LDCT) in workers previously exposed to asbestos: detection of parenchymal lung disease. *J Comput Assist Tomogr*. 37(4):626-30, 2013 Jul-Aug.

49. Tamura T, Suganuma N, Hering KG, et al. Relationships (I) of International Classification of High-resolution Computed Tomography for Occupational and Environmental Respiratory Diseases with the ILO International Classification of Radiographs of Pneumoconioses for parenchymal abnormalities. *Ind Health*. 2015;53(3):260-70.

50. Lavelle LP, Brady D, McEvoy S, et al. Pulmonary fibrosis: tissue characterization using late-enhanced MRI compared with unenhanced anatomic high-resolution CT. *Diagn Interv Radiol*. 2017;23(2):106-111.

51. Pinal-Fernandez I, Pineda-Sanchez V, Pallisa-Nuñez E, et al. Fast 1.5 T chest MRI for the assessment of interstitial lung disease extent secondary to systemic sclerosis. *Clin Rheumatol*. 2016 Sep;35(9):2339-45.

52. Mirsadraee S, Tse M, Kershaw L, et al. T1 characteristics of interstitial pulmonary fibrosis on 3T MRI-a predictor of early interstitial change?. *Quant Imaging Med Surg*. 2016 Feb;6(1):42-9.

53. 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 Apr;190(4):878-85.

54. Fujimoto N, Kato K, Usami I, et al. Asbestos-related diffuse pleural thickening. *Respiration*. 88(4):277-84, 2014.

55. Ergun D, Ergun R, Evcik E, Nadir Ozis T, Akkurt I. The relation between the extent of radiological findings and respiratory functions in pneumoconiosis cases of dental technicians who are working in Ankara. *Tuberkuloz ve Toraks*. 64(2):127-36, 2016 Jun.

56. Tiwari RR. Agreement between chest radiography and high-resolution computed tomography in diagnosing dust-related interstitial lung fibrosis. *Toxicol Ind Health*. 2015 Mar;31(3):235-8.

57. Larson TC, Franzblau A, Lewin M, Goodman AB, Antao VC. Impact of body mass index on the detection of radiographic localized pleural thickening. *Acad Radiol*. 21(1):3-10, 2014 Jan.

58. Xing J, Huang X, Yang L, Liu Y, Zhang H, Chen W. Comparison of high-resolution computerized tomography with film-screen radiography for the evaluation of opacity and the recognition of coal workers' pneumoconiosis. *J Occup Health*. 2014;56(4):301-8.

59. Laurent F, Paris C, Ferretti GR, et al. Inter-reader agreement in HRCT detection of pleural plaques and asbestosis in participants with previous occupational exposure to asbestos. *Occup Environ Med*. 71(12):865-70, 2014 Dec.

60. Perez-Alonso A, Cordoba-Dona JA, Millares-Lorenzo JL, Figueroa-Murillo E, Garcia-Vadillo

C, Romero-Morillos J. Outbreak of silicosis in Spanish quartz conglomerate workers. *Int J Occup Environ Health.* 20(1):26-32, 2014 Jan-Mar.

61. Kahraman H, Koksal N, Cinkara M, Ozkan F, Sucakli MH, Ekerbicer H. Pneumoconiosis in dental technicians: HRCT and pulmonary function findings. *Occupational Medicine (Oxford).* 64(6):442-7, 2014 Sep.
62. Costa C, Ascenti G, Scribano E, et al. CT patterns of pleuro-pulmonary damage caused by inhalation of pumice as a model of pneumoconiosis from non-fibrous amorphous silicates. *Radiologia Medica.* 121(1):19-26, 2016 Jan.
63. Siribaddana AD, Wickramasekera K, Palipana WM, et al. A study on silicosis among employees of a silica processing factory in the Central Province of Sri Lanka. *Ceylon Med J.* 61(1):6-10, 2016 Mar.
64. Arakawa H, Kishimoto T, Ashizawa K, et al. Asbestosis and other pulmonary fibrosis in asbestos-exposed workers: high-resolution CT features with pathological correlations. *Eur Radiol.* 26(5):1485-92, 2016 May.
65. Akira M, Yamamoto S, Inoue Y, Sakatani M. High-resolution CT of asbestosis and idiopathic pulmonary fibrosis. *AJR Am J Roentgenol.* 181(1):163-9, 2003 Jul.
66. Jeong YJ, Lee KS, Chung MP, Han J, Johkoh T, Ichikado K. Chronic hypersensitivity pneumonitis and pulmonary sarcoidosis: differentiation from usual interstitial pneumonia using high-resolution computed tomography. [Review]. *Semin Ultrasound CT MR.* 35(1):47-58, 2014 Feb.
67. de Castro MC, Ferreira AS, Irion KL, et al. CT quantification of large opacities and emphysema in silicosis: correlations among clinical, functional, and radiological parameters. *Lung.* 192(4):543-51, 2014 Aug.
68. Nunes H, Schubel K, Piver D, et al. Nonspecific interstitial pneumonia: survival is influenced by the underlying cause. *European Respiratory Journal.* 45(3):746-55, 2015 Mar.
69. Soumagne T, Chardon ML, Dournes G, et al. Emphysema in active farmer's lung disease. *PLoS ONE.* 12(6):e0178263, 2017.
70. Akira M, Morinaga K. The comparison of high-resolution computed tomography findings in asbestosis and idiopathic pulmonary fibrosis. *Am J Ind Med.* 59(4):301-6, 2016 Apr.
71. Schikowsky C, Felten MK, Eisenhawer C, Das M, Kraus T. Lung function not affected by asbestos exposure in workers with normal Computed Tomography scan. *Am J Ind Med.* 60(5):422-431, 2017 May.
72. Tamura T, Suganuma N, Hering KG, et al. Relationships (II) of International Classification of High-resolution Computed Tomography for Occupational and Environmental Respiratory Diseases with ventilatory functions indices for parenchymal abnormalities. *Ind Health.* 2015;53(3):271-9.
73. Vehmas T, Oksa P. Chest HRCT signs predict deaths in long-term follow-up among asbestos exposed workers. *Eur J Radiol.* 2014 Oct;83(10):S0720-048X(14)00345-3.
74. Terra-Filho M, Bagatin E, Nery LE, et al. Screening of miners and millers at decreasing levels of asbestos exposure: comparison of chest radiography and thin-section computed tomography. *PLoS ONE.* 10(3):e0118585, 2015.
75. Hekimoglu K, Sancak T, Tor M, Besir H, Kalaycioglu B, Gundogdu S. Fast MRI evaluation of

pulmonary progressive massive fibrosis with VIBE and HASTE sequences: comparison with CT. *Diagn Interv Radiol.* 2010 Mar;16(1):30-7.

76. Silva CI, Muller NL, Neder JA, et al. Asbestos-related disease: progression of parenchymal abnormalities on high-resolution CT. *J Thorac Imaging.* 2008;23(4):251-257.
77. Johannson KA, Elicker BM, Vittinghoff E, et al. A diagnostic model for chronic hypersensitivity pneumonitis. *Thorax.* 71(10):951-4, 2016 Oct.
78. Okamoto T, Miyazaki Y, Ogura T, et al. Nationwide epidemiological survey of chronic hypersensitivity pneumonitis in Japan. *Respir Investig.* 51(3):191-9, 2013 Sep.
79. Paris C, Herin F, Reboux G, et al. Working with argan cake: a new etiology for hypersensitivity pneumonitis. *BMC polm. med..* 15:18, 2015 Mar 06.
80. Miyazaki Y, Tateishi T, Akashi T, Ohtani Y, Inase N, Yoshizawa Y. Clinical predictors and histologic appearance of acute exacerbations in chronic hypersensitivity pneumonitis. *Chest.* 134(6):1265-70, 2008 Dec.
81. Walsh SL, Sverzellati N, Devaraj A, Wells AU, Hansell DM. Chronic hypersensitivity pneumonitis: high resolution computed tomography patterns and pulmonary function indices as prognostic determinants. *Eur Radiol.* 22(8):1672-9, 2012 Aug.
82. Morell F, Villar A, Montero MA, et al. Chronic hypersensitivity pneumonitis in patients diagnosed with idiopathic pulmonary fibrosis: a prospective case-cohort study. *The Lancet Respiratory Medicine.* 1(9):685-94, 2013 Nov.
83. Lima MS, Coletta EN, Ferreira RG, et al. Subacute and chronic hypersensitivity pneumonitis: histopathological patterns and survival. *Respir Med.* 103(4):508-15, 2009 Apr.
84. Chung JH, Zhan X, Cao M, et al. Presence of Air Trapping and Mosaic Attenuation on Chest Computed Tomography Predicts Survival in Chronic Hypersensitivity Pneumonitis. *Ann Am Thorac Soc.* 14(10):1533-1538, 2017 Oct.
85. Chung JH, Montner SM, Adegunsoye A, et al. CT findings associated with survival in chronic hypersensitivity pneumonitis. *Eur Radiol.* 27(12):5127-5135, 2017 Dec.
86. Jacob J, Bartholmai BJ, Egashira R, et al. Chronic hypersensitivity pneumonitis: identification of key prognostic determinants using automated CT analysis. *BMC polm. med..* 17(1):81, 2017 May 04.
87. Jacob J, Bartholmai BJ, Rajagopalan S, et al. Automated computer-based CT stratification as a predictor of outcome in hypersensitivity pneumonitis. *Eur Radiol.* 27(9):3635-3646, 2017 Sep.
88. Hanak V, Golbin JM, Hartman TE, Ryu JH. High-resolution CT findings of parenchymal fibrosis correlate with prognosis in hypersensitivity pneumonitis. *Chest.* 134(1):133-8, 2008 Jul.
89. Mooney JJ, Elicker BM, Urbania TH, et al. Radiographic fibrosis score predicts survival in hypersensitivity pneumonitis. *Chest.* 2013 Aug;144(2):S0012-3692(13)60536-X.
90. Tateishi T, Ohtani Y, Takemura T, et al. Serial high-resolution computed tomography findings of acute and chronic hypersensitivity pneumonitis induced by avian antigen. *J Comput Assist Tomogr.* 2011;35(2):272-9.
91. Morisset J, Johannson KA, Vittinghoff E, et al. Use of Mycophenolate Mofetil or

Azathioprine for the Management of Chronic Hypersensitivity Pneumonitis. *Chest*. 151(3):619-625, 2017 03.

92. van Rooy FG, Rooyackers JM, Prokop M, Houba R, Smit LA, Heederik DJ. Bronchiolitis obliterans syndrome in chemical workers producing diacetyl for food flavorings. *Am J Respir Crit Care Med*. 176(5):498-504, 2007 Sep 01.
93. Park HJ, Park SH, Im SA, Kim YK, Lee KY. CT differentiation of anthracofibrosis from endobronchial tuberculosis. *AJR Am J Roentgenol*. 191(1):247-51, 2008 Jul.
94. Han FF, Yang TY, Song L, et al. Clinical and pathological features and imaging manifestations of bronchial anthracofibrosis: the findings in 15 patients. *Chin Med J*. 126(14):2641-6, 2013 Jul.
95. Mathew L, Kirby M, Etemad-Rezai R, Wheatley A, McCormack DG, Parraga G. Hyperpolarized ^3He magnetic resonance imaging: preliminary evaluation of phenotyping potential in chronic obstructive pulmonary disease. *Eur J Radiol*. 79(1):140-6, 2011 Jul.
96. Zha W, Kruger SJ, Cadman RV, et al. Regional Heterogeneity of Lobar Ventilation in Asthma Using Hyperpolarized Helium-3 MRI. *Acad Radiol*. 25(2):169-178, 2018 Feb.
97. Tahir BA, Van Holsbeke C, Ireland RH, et al. Comparison of CT-based Lobar Ventilation with ^3He MR Imaging Ventilation Measurements. *Radiology*. 278(2):585-92, 2016 Feb.
98. Gast KK, Viallon M, Eberle B, et al. MRI in lung transplant recipients using hyperpolarized ^3He : comparison with CT. *J Magn Reson Imaging*. 15(3):268-74, 2002 Mar.
99. Puderbach M, Eichinger M, Haeselbarth J, et al. Assessment of morphological MRI for pulmonary changes in cystic fibrosis (CF) patients: comparison to thin-section CT and chest x-ray. *Invest Radiol*. 42(10):715-25, 2007 Oct.
100. Capaldi DPI, Eddy RL, Svenningsen S, et al. Free-breathing Pulmonary MR Imaging to Quantify Regional Ventilation. *Radiology*. 287(2):693-704, 2018 05.
101. Kuramochi J, Inase N, Miyazaki Y, Kawachi H, Takemura T, Yoshizawa Y. Lung cancer in chronic hypersensitivity pneumonitis. *Respiration*. 82(3):263-7, 2011.
102. Hung YP, Teng CJ, Liu CJ, et al. Cancer risk among patients with coal workers' pneumoconiosis in Taiwan: a nationwide population-based study. *Int J Cancer*. 134(12):2910-6, 2014 Jun 15.
103. Fitzgerald NR, Flanagan WM, Evans WK, Miller AB, Canadian Partnership against Cancer (CPAC) Cancer Risk Management (CRM) Lung Cancer Working. Eligibility for low-dose computerized tomography screening among asbestos-exposed individuals. *Scand J Work Environ Health*. 41(4):407-12, 2015 Jul.
104. Das M, Muhlenbruch G, Mahnken AH, et al. Asbestos Surveillance Program Aachen (ASPA): initial results from baseline screening for lung cancer in asbestos-exposed high-risk individuals using low-dose multidetector-row CT. *Eur Radiol*. 2007;17(5):1193-1199.
105. Roberts HC, Patsios DA, Paul NS, et al. Screening for malignant pleural mesothelioma and lung cancer in individuals with a history of asbestos exposure. *J Thorac Oncol*. 4(5):620-8, 2009 May.
106. Piron JC, Andujar P, Rinaldo M, et al. Asbestos exposure, pleural plaques, and the risk of death from lung cancer. *Am J Respir Crit Care Med*. 190(12):1413-20, 2014 Dec 15.

107. Pairen JC, Laurent F, Rinaldo M, et al. Pleural plaques and the risk of pleural mesothelioma. *J Natl Cancer Inst.* 105(4):293-301, 2013 Feb 20.

108. Vierikko T, Jarvenpaa R, Autti T, et al. Chest CT screening of asbestos-exposed workers: lung lesions and incidental findings. *Eur Respir J.* 2007;29(1):78-84.

109. Hallifax RJ, Haris M, Corcoran JP, et al. Role of CT in assessing pleural malignancy prior to thoracoscopy. *Thorax.* 2015;70(2):192-193.

110. Kato K, Gemba K, Ashizawa K, et al. Low-dose chest computed tomography screening of subjects exposed to asbestos. *European Journal of Radiology.* 101:124-128, 2018 Apr.

111. Tsim S, Stobo DB, Alexander L, Kelly C, Blyth KG. The diagnostic performance of routinely acquired and reported computed tomography imaging in patients presenting with suspected pleural malignancy. *Lung Cancer.* 103:38-43, 2017 01.

112. de Groot PM, Chung JH, et al. ACR Appropriateness Criteria® Noninvasive Clinical Staging of Primary Lung Cancer. *J Am Coll Radiol.* 2019 May;16(5S):S1546-1440(19)30148-6.

113. Ogihara Y, Ashizawa K, Hayashi H, et al. Progressive massive fibrosis in patients with pneumoconiosis: utility of MRI in differentiating from lung cancer. *Acta Radiol.* 59(1):72-80, 2018 Jan.

114. Gill RR, Umeoka S, Mamata H, et al. Diffusion-weighted MRI of malignant pleural mesothelioma: preliminary assessment of apparent diffusion coefficient in histologic subtypes. *AJR Am J Roentgenol.* 2010;195(2):W125-130.

115. Patel AM, Berger I, Wileyto EP, et al. The value of delayed phase enhanced imaging in malignant pleural mesothelioma. *J. thorac. dis.* 9(8):2344-2349, 2017 Aug.

116. Usuda K, Maeda S, Motono N, et al. Diagnostic Performance of Diffusion-Weighted Imaging for Multiple Hilar and Mediastinal Lymph Nodes with FDG Accumulation. *Asian Pac J Cancer Prev.* 16(15):6401-6, 2015.

117. Weber MA, Bock M, Plathow C, et al. Asbestos-related pleural disease: value of dedicated magnetic resonance imaging techniques. *Invest Radiol.* 2004;39(9):554-564.

118. Chung SY, Lee JH, Kim TH, Kim SJ, Kim HJ, Ryu YH. 18F-FDG PET imaging of progressive massive fibrosis. *Ann Nucl Med.* 24(1):21-7, 2010 Jan.

119. Reichert M, Bensadoun ES. PET imaging in patients with coal workers pneumoconiosis and suspected malignancy. *J Thorac Oncol.* 2009;4(5):649-651.

120. Yildirim H, Metintas M, Entok E, et al. Clinical value of fluorodeoxyglucose-positron emission tomography/computed tomography in differentiation of malignant mesothelioma from asbestos-related benign pleural disease: an observational pilot study. *J Thorac Oncol.* 2009;4(12):1480-1484.

121. Roca E, Laroumagne S, Vandemoortele T, et al. 18F-fluoro-2-deoxy-d-glucose positron emission tomography/computed tomography fused imaging in malignant mesothelioma patients: looking from outside is not enough. *Lung Cancer.* 79(2):187-90, 2013 Feb.

122. Pilling J, Dartnell JA, Lang-Lazdunski L. Integrated positron emission tomography-computed tomography does not accurately stage intrathoracic disease of patients undergoing trimodality therapy for malignant pleural mesothelioma. *Thorac Cardiovasc Surg.* 2010;58(4):215-219.

123. Khouri NF, Stitik FP, Erozan YS, et al. Transthoracic needle aspiration biopsy of benign and malignant lung lesions. *AJR Am J Roentgenol.* 144(2):281-8, 1985 Feb.

124. Li H, Boiselle PM, Shepard JO, Trotman-Dickenson B, McLoud TC. Diagnostic accuracy and safety of CT-guided percutaneous needle aspiration biopsy of the lung: comparison of small and large pulmonary nodules. *AJR Am J Roentgenol.* 167(1):105-9, 1996 Jul.

125. Wallace MJ, Krishnamurthy S, Broemeling LD, et al. CT-guided percutaneous fine-needle aspiration biopsy of small (< or =1-cm) pulmonary lesions. *Radiology.* 2002; 225(3):823-828.

126. Arakawa H, Shida H, Saito Y, et al. Pulmonary malignancy in silicosis: factors associated with radiographic detection. *Eur J Radiol.* 69(1):80-6, 2009 Jan.

127. American College of Radiology. ACR Appropriateness Criteria® Radiation Dose Assessment Introduction. Available at: <https://edge.sitecorecloud.io/americanoldf5f-acrorgf92a-productioncb02-3650/media/ACR/Files/Clinical/Appropriateness-Criteria/ACR-Appropriateness-Criteria-Radiation-Dose-Assessment-Introduction.pdf>.

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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.

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