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American College of Radiology
ACR Appropriateness Criteria®

Clinical Condition: **Occupational Lung Diseases**

Variant 1: **Silica exposure, suspected silicosis.**

Radiologic Procedure	Rating	Comments	RRL*
X-ray chest	9	X-ray chest and CT chest without contrast are complementary. Both should be performed.	☢
CT chest without IV contrast	9	X-ray chest and CT chest without contrast are complementary. Both should be performed.	☢☢☢
CT chest with IV contrast	3		☢☢☢
FDG-PET/CT chest	3		☢☢☢☢
CT chest without and with IV contrast	2		☢☢☢
MRI chest without and with IV contrast	2		O
MRI chest without IV contrast	2		O
Rating Scale: 1,2,3 = Usually not appropriate; 4,5,6 = May be appropriate; 7,8,9 = Usually appropriate			*Relative Radiation Level

Variant 2: **Coal dust exposure, suspected pneumoconiosis.**

Radiologic Procedure	Rating	Comments	RRL*
CT chest without IV contrast	9	X-ray chest and CT chest without contrast are complementary. Both should be performed.	☢☢☢
X-ray chest	8	X-ray chest and CT chest without contrast are complementary. Both should be performed.	☢
CT chest with IV contrast	4		☢☢☢
FDG-PET/CT chest	3		☢☢☢☢
MRI chest without and with IV contrast	2		O
MRI chest without IV contrast	2		O
CT chest without and with IV contrast	2		☢☢☢
Rating Scale: 1,2,3 = Usually not appropriate; 4,5,6 = May be appropriate; 7,8,9 = Usually appropriate			*Relative Radiation Level

Clinical Condition: **Occupational Lung Diseases**

Variant 3: **Asbestos exposure, suspected interstitial lung disease.**

Radiologic Procedure	Rating	Comments	RRL*
CT chest without IV contrast	9	X-ray chest and CT chest without contrast are complementary. Both should be performed.	☢☢☢
X-ray chest	8	X-ray chest and CT chest without contrast are complementary. Both should be performed.	☢
CT chest with IV contrast	3		☢☢☢
FDG-PET/CT chest	3		☢☢☢☢
MRI chest without and with IV contrast	2		O
MRI chest without IV contrast	2		O
CT chest without and with IV contrast	2		☢☢☢
Rating Scale: **1,2,3 = Usually not appropriate; 4,5,6 = May be appropriate; 7,8,9 = Usually appropriate**			***Relative Radiation Level**

Variant 4: **Asbestos exposure, suspected mesothelioma.**

Radiologic Procedure	Rating	Comments	RRL*
CT chest with IV contrast	9	X-ray chest and CT chest are complementary. Both should be performed.	☢☢☢
X-ray chest	8	X-ray chest and CT chest are complementary. Both should be performed.	☢
CT chest without IV contrast	7	X-ray chest and CT chest are complementary. Both should be performed.	☢☢☢
FDG-PET/CT chest	6		☢☢☢☢
MRI chest without and with IV contrast	5	This procedure may be appropriate, but there was disagreement among panel members on the appropriateness rating as defined by the panel's median rating.	O
CT chest without and with IV contrast	3		☢☢☢
MRI chest without IV contrast	3		O
Rating Scale: **1,2,3 = Usually not appropriate; 4,5,6 = May be appropriate; 7,8,9 = Usually appropriate**			***Relative Radiation Level**

OCCUPATIONAL LUNG DISEASES

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Summary of Literature Review

Introduction/Background

Occupational lung disease is a broad category of disease entities characterized by a non-neoplastic reaction of the lung parenchyma to inhaled aerosolized particles found in the environment, typically from work-related exposure. The term "pneumoconiosis" refers to diseases associated with the inhalation of inorganic mineral dusts. This paper reviews the 3 most common inorganic occupational lung diseases: silicosis, coal worker pneumoconiosis, and asbestosis. The less common inorganic occupational lung diseases include, but are not limited to, berylliosis, talcosis, hard metal pneumoconiosis, and flavorings-related lung disease.

Overview of Imaging Modalities

Chest radiography is one of the primary imaging modalities used to evaluate the pneumoconioses and has traditionally been performed by analog technique [1]. The International Labor Organization (ILO) developed a well-recognized classification scheme for chest radiography to objectively classify lung opacities based on their size, shape, and profusion.

However, with evolution of modern imaging techniques such as digital radiography, analog radiography has largely been replaced [1]. In 2011 the ILO updated its guidelines for evaluation of pneumoconiosis by extending the applicability of its classification scheme to digital radiography [2].

There is still no standardized scoring system available for high-resolution computed tomography (HRCT), even though there is significant improvement of resolution and improved ability to detect more subtle abnormalities as compared to chest radiography. Despite this fact, HRCT is still a valuable tool for the evaluation of lungs in patients with this category of disease.

Magnetic resonance imaging (MRI), though known to be limited in detecting abnormalities in the predominantly air-filled lungs, may have a role in evaluation of some parenchymal and pleural abnormalities. Positron emission tomography (PET) also has a limited role for the evaluation of the occupational lung diseases, and its role in staging malignant mesothelioma is controversial. The specific imaging findings associated with occupational lung diseases are well described in the literature and are beyond the scope of this article.

Discussion of the Imaging Modalities by Variant

Variant 1: Silica Exposure, Suspected Silicosis

Chest radiography and HRCT are the primary imaging modalities employed in the evaluation of silicosis. However, HRCT has been shown in the literature as being more sensitive for the detection of parenchymal findings associated with silica-related lung disease. In a study by Sun et al [3] the authors studied 90 patients exposed to silica in mine machinery manufacturing workers. They observed that the number of small opacities detected by HRCT scans were significantly higher than those seen in radiography in all lung zones. When these researchers compared radiography versus HRCT for the detection of complications of silicosis, there was a statistically significant increase in the detectability of bulla, emphysema, and pleural changes in addition to lymphadenopathy. Ooi et al [4] demonstrated that 10 of 26 patients who were determined to have simple silicosis on chest radiography were upgraded to complicated silicosis (progressive massive fibrosis [PMF]) at HRCT

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examination. Similarly, in a study performed by Lopes et al [5], 13 of 32 individuals with a history of silica dust exposure and a normal chest radiograph demonstrated evidence of silicosis on HRCT.

Both severities of findings on chest radiography and HRCT correlate with a reduction in lung function in patients with silicosis. Ooi et al [4] studied 76 men with proven silicosis and demonstrated a linear relationship between the severity of both HRCT and chest radiography findings with respect to lung functional parameters. They determined that the severity of PMF had an inverse correlation with patients' pulmonary function tests. Furthermore, they determined that although both chest radiography and HRCT demonstrated an inverse relationship to all lung functional parameters, the strongest relationship was comparing HRCT findings of PMF and nodular profusion index to lung functional parameters. They conclude by suggesting that CT may be used to indirectly quantify functional impairment. Interestingly, Lopes et al [5] observed that small opacities on HRCT had no significant negative effect on lung function. However, large opacities were associated with a decrease in diffusing capacity of the lung for carbon monoxide. The inference is that the size of lung opacities correlates with severity of disease, a conclusion similar to that reached by Ooi et al [4]. A study by Antao et al [6] comparing HRCT to pulmonary function tests concluded that profusion of opacities on HRCT correlates with functional deterioration as well.

In an article by Arakawa et al [7], the authors used inspiratory and expiratory thin CT scans in 37 patients with silicosis and determined that air trapping was the best measure of assessment of obstructive disease in this population.

Variant 2: Coal Dust Exposure, Suspected Pneumoconiosis

Recent literature interrogation specifically on the data for imaging appropriateness of coal worker pneumoconiosis yielded few results. However, one article from Savranlar et al [8] compared chest radiography with HRCT in patients with early and low-grade coal worker pneumoconiosis and questioned the utility of radiography in screening of these patients. Their study population included a final population of 67 patients with at least 10 years of exposure to coal dust and no history of pulmonary disease. They used the ILO grading schematic for chest radiography and the Hosoda-Shida Classification of CT for pneumoconiosis to categorize lung abnormalities. In addition to demonstrating improved sensitivity for detection of lung opacities by HRCT, the investigators also observed a high discordance rate between chest radiography and HRCT. In the study, 28 of 67 patients (42%) initially categorized with chest radiography were placed in a different category of lung abnormality after HRCT assessment. The authors conclude that HRCT should be used in the screening of this specific patient population because HRCT is more sensitive and better categorizes the lung abnormality as compared to chest radiography.

Recent advancements in imaging technology have led to the study of PMF using MRI. Hekimoglu et al [9] compared CT and MRI findings of 22 cases of histologically confirmed PMF in 20 coal miners and concluded that there is potential clinical use for MRI in evaluation of PMF lesions in pneumoconiosis. The investigators observed that all of the lesions detected on CT were identified on the MRI comparison study and MRI interpretations did not demonstrate false-positive or false-negative findings with respect to the presence of PMF on CT. The authors state MRI could be an alternative modality, particularly if minimizing exposure to ionizing radiation is of concern. They also state that additional studies are warranted to establish the clinical value of MRI in patients with various pulmonary diseases.

There are limited data on PET imaging of suspected lung cancer in patients with coal worker pneumoconiosis. However, Reichert and Bensadoun [10] observed 6 cases where PET was used in this specific setting. They observed the presence of 18 of 19 nodules that were hypermetabolic in the range typically seen with malignancy. However, none of these nodules were determined to be malignant, thus they concluded that PET imaging is of limited utility given the high false-positive rate.

Variants 3 and 4: Asbestos Exposure, Suspected Interstitial Lung Disease or Mesothelioma

Chest radiography is the primary method of screening for asbestos-related interstitial lung diseases; however, CT is more sensitive for the detection of lung abnormalities and complications related to asbestos exposure [11]. Spyratos et al [11] studied 266 employees from an asbestos cement plant that used chrysotile exclusively. Chest radiography detected abnormal findings in approximately 21% of the employees, whereas HRCT detected 67%. Interestingly, the investigators observed that lung function correlated with parenchymal and visceral pleural abnormalities on HRCT. Vierikko et al [12] studied chest CT screening in asbestos-exposed workers and observed 6 lung cancers, including 1 pleural mesothelioma, identified by CT, and only 1 cancer identified by chest radiography. The authors concluded that despite additional confounding findings, CT was better than radiography in detecting lung cancer in individuals exposed to asbestos. Although lacking a chest radiograph control group, Das et al [13] assessed the prevalence of lung cancer using low-dose multidetector CT in a cohort of 187 asbestos exposed high-risk patients. The investigators observed 8 lung malignancies in 187 individuals. In a ninth individual there was strong suspicion for lung malignancy, but that patient died before further workup. In a study by Silva et al [14], the authors demonstrated the progression of mild asbestos-related lung parenchymal abnormalities in 81% of patients after a 3-year to 5-year follow-up using HRCT.

A study performed by Muravov et al [15] demonstrated improved detection of pleural abnormalities by HRCT over chest radiography alone in a cohort of individuals exposed to vermiculite-containing asbestos. The authors detected pleural abnormalities by HRCT in nearly 28% of the individuals whose chest radiographs were indeterminate. Similarly, Elshazley et al [16] observed that chest radiography could not detect pleural plaques located in a paravertebral location, whereas CT was able to identify 89 paravertebral pleural plaques. Finally, Weber at al [17] sought to evaluate the use of MRI in assessment of asbestos-related pleural abnormalities. The researchers observed a comparable interobserver agreement for the detection of pleural plaques and higher interobserver agreement in the detection of pleural thickening and pleural effusion than compared with CT. For the detection of mesothelioma, they found no significant difference between the kappa values for MRI and CT. Furthermore, Gill et al [18] suggested that apparent diffusion coefficient maps may be useful in discriminating different histological subtypes of malignant pleural mesothelioma and may complement other MRI sequences in the evaluation of mesothelioma as well.

Yildirim et al [19] studied a cohort of 31 patients with pleural disease related to asbestos exposure to determine the use of PET/CT in discriminating between benign pleural disease and malignant mesothelioma. The authors observed that PET/CT identified 15 of 17 cases of malignant mesothelioma based on metabolic activity. Thirteen of 14 benign pleural lesions were considered negative by PET/CT. Using a SUVmax threshold of 2.2, the sensitivity, specificity, positive predictive value, and negative predictive value were 94.1%, 100%, 100%, and 93.3% respectively. They concluded that PET/CT is useful for discriminating benign pleural disease from malignant mesothelioma.

Pilling et al [20] retrospectively studied the use of PET/CT staging of malignant pleural mesothelioma in 20 patients undergoing trimodality therapy. They observed that PET/CT failed to identify advanced tumor stage and had a sensitivity of only 11% for the detection of mediastinal nodal disease. They concluded that the role for PET/CT is in excluding patients with metastatic disease outside the affected hemithorax prior to extrapleural pneumonectomy.

Summary of Recommendations

- Workup of occupational lung diseases usually begins with routine chest radiography. However, the greater resolution of CT chest over chest radiography allows for more sensitive and accurate detection and characterization of lung and pleural abnormalities.
- CT chest without contrast suffices for routine analysis of patients with occupational lung disease in most scenarios. In some situations, utilizing contrast-enhanced CT chest may be of utility if there is a clinical question of pulmonary embolism and in assessing for adenopathy/masses. Rarely is there a need for performing CT chest without and with contrast.
- FDG-PET may have utility in patients with suspected mesothelioma in terms of defining mediastinal and distal metastatic disease and perhaps localizing a potential biopsy site. Otherwise, the role of FDG-PET is limited.
- In general, MRI is not regarded as appropriate in the evaluation of occupational lung diseases.

Summary of Evidence

Of the 20 references cited in the *ACR Appropriateness Criteria® Occupational Lung Diseases* document, all of them are categorized as diagnostic references, 3 well-designed studies, 6 good quality studies, and 5 quality studies that may have design limitations. There are 6 references that may not be useful as primary evidence.

The 20 references cited in the *ACR Appropriateness Criteria® Occupational Lung Diseases* document were published between 2003–2012.

While there are references that report on studies with design limitations, 9 well-designed or good quality studies provide good evidence.

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, both because of 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 to 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**
O	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.

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