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# ACR Appropriateness Criteria<sup>®</sup> on Acute Respiratory Illness

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In a patient with acute respiratory illness (cough, sputum production, chest pain, and/or dyspnea), the need for chest imaging depends on the severity of illness, age of the patient, clinical history, physical and laboratory findings, and other risk factors. Chest radiographs seem warranted when one or more of the following are present: age  $\geq 40$ ; dementia; a positive physical examination; hemoptysis; associated abnormalities (leukocytosis, hypoxemia); or other risk factors, including coronary artery disease, congestive heart failure, or drug-induced acute respiratory failure. Chest CT may be warranted in complicated cases of severe pneumonia and in febrile neutropenic patients with normal or nonspecific chest radiographic findings. Literature on the indications and usefulness of radiologic studies for acute respiratory illness in different clinical settings is reviewed.

**Key Words:** Appropriateness criteria, pneumonia, diagnostic imaging

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## SUMMARY OF LITERATURE REVIEW

Acute respiratory illness (ARI) is defined as  $\geq 1$  of the following: cough, sputum production, chest pain, or dyspnea (with or without fever). The workup of a patient with ARI, including the need for chest radiography and

computed tomography (CT), depends on many factors, including the severity of the illness; the age of the patient; the presence of fever, leukocytosis, or hypoxemia; clinical history; the presence of other risk factors; and the results of physical examination. Not all studies concur as to which patients with ARI should undergo chest radiography.

In a study of 1,102 outpatients with ARI, Benacerraf et al [1] found patient age, the results of physical examination, and the presence or absence of hemoptysis to be important factors. Only 4% of patients (7 of 175) aged  $<40$  years with symptoms of ARI, negative results on physical examination, and no hemoptysis had acute significant radiographic findings, whereas patients either aged  $>40$  years with hemoptysis or with positive results on physical examination had a much higher incidence of chest radiographic abnormalities (Variants 1-3).

In a study of 464 patients with ARI, Heckerling [2] also found a low incidence (3%) of pneumonia in patients with negative results on physical examination. A notable exception was found for patients with dementia, in whom the incidence of pneumonia was very high regardless of the results of physical examination (Variant 4).

Okimoto et al [3] studied 79 outpatients presenting with clinical suspicion of pneumonia and concluded that radiographs should be ordered only when patients present with fever, cough, sputum production, and coarse crackles on physical examination. Conversely, in a study of 221 patients with ARI, Butcher et al [4] found that 77 (35%) had new clinically important findings.

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**Variant 1. Age >40 years**

Radiologic Procedure	Rating	Comments	RRL
X-ray chest	8		Minimal
CT chest without contrast	4		Medium

Note: Rating scale: 1 = least appropriate, 9 = most appropriate. CT = computed tomography; RRL = relative radiation level.

Furthermore, the clinical findings did not differ significantly between those with positive radiographic findings and those with negative findings (ie, clinical history and physical examination were poor predictors of radiography-detected abnormality).

Speets et al [5] evaluated 192 patients with clinical suspicion of pneumonia by general practitioners and found that the probability of pneumonia was changed by chest radiographic results in 53% of patients, with decreases in probability in 47% and increases in probability in 6%.

In a series of 300 patients with acute cough illness, Aagaard et al [6] found that for patients with high pretest probability of pneumonia, radiographs were not always obtained in clinical practice; they inferred that when the clinical probability of pneumonia exceeds a certain level, negative radiographic findings would not alter treatment decisions by clinicians. A series by Basi et al [7] that included 2,706 patients hospitalized with community-acquired pneumonia similarly showed that 911 patients (one-third) had radiographic findings initially interpreted as negative for pneumonia, with minimal change in these interpretations on retrospective review of a random subgroup. The groups with positive and negative radiographic findings had similar rates of positive sputum cultures and blood cultures. These two studies call into question the utility of radiographs in patients with high pretest probability of pneumonia.

Patients with substance abuse have an increased risk for ARI due to two mechanisms: respiratory pump failure

**Variant 2. Age <40 years, negative results on physical examination, and no other signs, symptoms, or risk factors**

Radiologic Procedure	Rating	Comments	RRL
X-ray chest	4		Minimal
CT chest without contrast	1		Medium

Note: Rating scale: 1 = least appropriate, 9 = most appropriate. CT = computed tomography; RRL = relative radiation level.

**Variant 3. Age <40 years, positive results on physical examination, or other risk factors**

Radiologic Procedure	Rating	Comments	RRL
X-ray chest	9		Minimal
CT chest without contrast	4		Medium

Note: Rating scale: 1 = least appropriate, 9 = most appropriate. CT = computed tomography; RRL = relative radiation level.

and pulmonary pathology [8]. Respiratory pump failure generally does not have radiographic manifestations. However, pulmonary pathology includes multiple diagnoses with chest radiographic manifestations, including aspiration, pulmonary edema, pneumonia, hemorrhage, and septic emboli.

Jochelson et al [9] found a low incidence (4%) of pneumonia in febrile, but otherwise asymptomatic, neutropenic patients with normal results on physical examination (Variant 5). Navigante et al [10] found a similarly low incidence (2.3%) of pneumonia on chest radiography in febrile neutropenic patients without clinical suspicion of pneumonia from history or physical examination. Heussel et al [11] evaluated the utility of thin-section CT in a group of febrile neutropenic patients with normal or nonspecific chest radiographic findings. There were 146 episodes in 87 patients. Among the 14% with nonspecific chest radiographic findings, CT suggested pneumonia in all. Forty-eight percent had normal findings on chest radiography but computed tomographic findings of pneumonia. Of these, specific pathogens were identified in 43%. Both chest radiographic and computed tomographic findings were normal in 38%. The computed tomographic findings changed patients' therapy in 18%. Maertens et al [12] proposed an algorithm using CT in conjunction with galactomannan assays to select patients for high-dose antifungal therapy and performed a feasibility study assessing patients with 117 episodes of neutropenic fever. When the algorithm with CT was used, only 4.4% of patients received antifungal

**Variant 4. Dementia, any age**

Radiologic Procedure	Rating	Comments	RRL
X-ray chest	8		Minimal
CT chest without contrast	4		Medium

Note: Rating scale: 1 = least appropriate, 9 = most appropriate. CT = computed tomography; RRL = relative radiation level.

**Variant 5. Febrile, neutropenic**

Radiologic Procedure	Rating	Comments	RRL
X-ray chest	9		Minimal
CT chest with or without contrast	8	If results on chest radiography are normal or equivocal.	Medium

Note: Rating scale: 1 = least appropriate, 9 = most appropriate. CT = computed tomography; RRL = relative radiation level.

therapy. Hachem et al [13] retrospectively analyzed computed tomographic scans and autopsy results in 96 cancer patients who died of pneumonia and found that the presence of nodules in neutropenic patients and cavitory lesions in nonneutropenic patients was highly associated with fungal infection.

According to the guidelines of the Infectious Diseases Society of America and the American Thoracic Society, chest radiography should be obtained whenever pneumonia is suspected in adults to establish the diagnosis and to aid in differentiating community-acquired pneumonia from other common causes of cough and fever, such as acute bronchitis [14]. Findings on chest radiography are among several parameters used to determine 1) which patients should be hospitalized (presence of pleural effusion), 2) which patients should be classified as having severe pneumonia (multilobar involvement), and 3) which patients may require additional diagnostic testing (cavitation, pleural effusion), including thoracentesis (pleural effusions >5 cm on lateral upright radiography) [14]. Computed tomography may show findings in patients with normal radiographic findings, but the significance of these findings and therefore the utility of CT in patients with clinically suspected pneumonia and negative radiographs are unclear [14]. Computed tomography may play a role in the management of severe pneumonia (Variant 6). It can serve as a guide for pleural drainage or localize an appropriate site for biopsy [15]. Severe pneumonias bear a strong relationship to etiologic pathogens and have implications for antimicrobial treatment. Patients with severe pneumonia should be considered as candidates for admission to an intensive care unit.

**Variant 6. Complicated pneumonia**

Radiologic Procedure	Rating	Comments	RRL
X-ray chest	9		Minimal
CT chest with or without contrast	8	If pneumonia is not resolving or intervention is contemplated.	Medium

Note: Rating scale: 1 = least appropriate, 9 = most appropriate. CT = computed tomography; RRL = relative radiation level.

**Variant 7. Acute asthma uncomplicated**

Radiologic Procedure	Rating	Comments	RRL
X-ray chest	4		Minimal
CT chest without contrast	1		Medium

Note: Rating scale: 1 = least appropriate, 9 = most appropriate. CT = computed tomography; RRL = relative radiation level.

The need for chest radiography in adult patients with acute asthma is controversial (Variant 7). Petheram et al [16] found clinically important (ie, patient management was affected) radiographic findings in 9% of their patients and concluded that chest radiography is indicated. However, Findley and Sahn [17] observed that 99% of their patients either had normal chest radiographic findings or showed only slightly prominent markings or hyperinflation. Heckerling [2] reported that patients with acute asthma rarely have pneumonia. Findley and Sahn [17] recommended chest radiography only when pneumonia or pneumothorax is suspected (Variant 8). White et al [18] found significant chest radiographic abnormalities in 34% of adults whose asthma exacerbation warranted admission to the hospital.

Sherman et al [19] studied the utility of chest radiography in 242 patients with acute exacerbations of chronic obstructive pulmonary disease (ie, dyspnea) (Variants 9-10). Of this group, 135 patients (56%) had asthma, and 107 (44%) had emphysema and chronic bronchitis. Chest radiographic findings were abnormal in 14% but resulted in significant changes in management in only 4.5%. They concluded that chest radiography is indicated only if worsening dyspnea is accompanied by leukocytosis, chest pain, or edema or by a history of coronary artery disease or congestive heart failure.

Emerging infections and biologic warfare agents have come to recent attention as causes of ARI. Two infections that received a great deal of attention recently but have

**Variant 8. Acute asthma, suspected pneumonia, pneumothorax**

Radiologic Procedure	Rating	Comments	RRL
X-ray chest	9		Minimal
CT chest without contrast	2		Medium

Note: Rating scale: 1 = least appropriate, 9 = most appropriate. CT = computed tomography; RRL = relative radiation level.

**Variant 9.** Acute exacerbation of chronic obstructive pulmonary disease, “uncomplicated” (no history of coronary artery disease or congestive heart failure, no leukocytosis, fever, or chest pain)

Radiologic Procedure	Rating	Comments	RRL
X-ray chest	4		Minimal
CT chest without contrast	2		Medium

Note: Rating scale: 1 = least appropriate, 9 = most appropriate. CT = computed tomography; RRL = relative radiation level.

subsequently become less active concerns are severe acute respiratory syndrome (SARS) and anthrax.

Severe acute respiratory syndrome emerged in China in late 2002. The etiologic agent is a novel coronavirus (SARS-CoV) that seems to have originated in Himalayan palm civets and crossed the species barrier. In February 2003, the Program for Monitoring Emerging Diseases identified this novel presentation of pneumonia, which because of air travel rapidly spread across continents to involve patients in  $\geq 27$  countries. There is literature supporting the utility of chest radiography in patients with known or suspected SARS (Variant 11). Wong et al [20] and Paul et al [21] described the chest radiographic findings of SARS during the Hong Kong and Toronto epidemics. Chest radiographic findings were abnormal in 78% to 80% of patients at presentation. The most common chest radiographic finding was unifocal opacity with a peripheral and basilar predominance. Multifocal or diffuse opacities could be present initially or develop as the disease progressed. Patients whose disease progressed were generally older, had more comorbidities, and had a higher fatality rate. Cavitation, pleural effusion, and lymphadenopathy were not features of SARS. Antonio et al [22] studied 1,373 patients in Hong Kong with SARS and found a sensitivity for disease of 82.4% on initial

**Variant 10.** Acute exacerbation of chronic obstructive pulmonary disease with  $\geq 1$  of the following: leukocytosis, pain, history of coronary artery disease or congestive heart failure

Radiologic Procedure	Rating	Comments	RRL
X-ray chest	9		Minimal
CT chest without contrast	4		Medium

Note: Rating scale: 1 = least appropriate, 9 = most appropriate. CT = computed tomography; RRL = relative radiation level.

**Variant 11.** Suspected severe acute respiratory syndrome

Radiologic Procedure	Rating	Comments	RRL
X-ray chest	9		Minimal
CT chest without contrast	9	If results on chest radiography are normal or equivocal.	Medium

Note: Rating scale: 1 = least appropriate, 9 = most appropriate. CT = computed tomography; RRL = relative radiation level.

chest radiographs; they also concluded that the initial extent of radiographic opacification had prognostic value and that the rate of radiographic progression could be used as a prognostic indicator.

Thin-section chest computed tomographic findings of SARS have been described by Wong et al [23], Chan et al [24], and Paul et al [21]. The most common findings are ground-glass opacities and crazy paving. More extensive findings include focal or multifocal consolidation. Chan et al [24] described pleural effusions and pneumomediastinum developing in 26% of patients scanned during the course of their illness. Hui et al [25] suggest that high-resolution CT is useful for the early diagnosis of SARS in patients with negative chest radiographic findings. They studied 47 patients with suspected SARS and normal chest radiographic findings; 25 of 27 patients with serologic confirmation of SARS had abnormal findings on high-resolution CT and developed clinical SARS, while the 2 with negative findings on high-resolution CT did not develop pulmonary infection.

Anthrax is endemic in the soil of Texas, Oklahoma, and the Mississippi Valley. During the 20th century, a number of countries developed weapon-grade anthrax to be used as a biologic warfare agent [26]. Much of modern medical experience with it arises from a Soviet military accident in 1979 in which 42 people died of anthrax and from cases of anthrax that developed in the US in 2001 as a result of biologic warfare. Anthrax comes in 3 forms: cutaneous, gastrointestinal, and inhalational. Ninety-five percent of anthrax is cutaneous, but the inhalational form is the most deadly. Inhalation of anthrax spores leads to hemorrhagic lymphadenitis and mediastinitis,

**Variant 12.** Suspected anthrax

Radiologic Procedure	Rating	Comments	RRL
X-ray chest	9		Minimal
CT chest with or without contrast	8	If results on chest radiography are normal or equivocal.	Medium

Note: Rating scale: 1 = least appropriate, 9 = most appropriate. CT = computed tomography; RRL = relative radiation level.



sometimes accompanied by necrotizing pneumonia (Variant 12). The chest radiographic findings [26,27] include widened mediastinum and hila, often accompanied by pleural effusions and parenchymal opacities. Earls et al [27] described the computed tomographic findings in two patients who survived inhalational anthrax. The computed tomographic characteristics were very suggestive of the diagnosis and included hyperattenuating hilar and mediastinal lymphadenopathy and hemorrhagic pleural effusion. Less specific findings included mediastinal edema, peribronchial thickening, and pleural effusion.

## SUMMARY

On the basis of these studies, chest radiography seems warranted in ARI when  $\geq 1$  of the following is present: age  $>40$  years; dementia; positive results on physical examination; hemoptysis; associated abnormalities (leukocytosis, hypoxemia); or other risk factors, including coronary artery disease, congestive heart failure, or drug-induced acute respiratory failure. Chest radiography also seems warranted for any adult patient with clinical suspicion of pneumonia, although some clinicians may choose not to perform radiography if clinical suspicion of respiratory infection is sufficiently high to warrant treatment if the results of radiography were to be negative. It seems that in patients with ARI who are aged  $<40$  years, chest radiography is not routinely indicated unless there are other abnormalities, positive results on physical examination, or other risk factors. It also seems that chest radiography is not indicated in most patients with exacerbations of chronic obstructive pulmonary disease (including asthma), unless there is a suspected complication such as pneumonia or pneumothorax or unless  $\geq 1$  of the following is present: leukocytosis, chest pain, edema, or a history of coronary artery disease or congestive heart failure. Chest CT may be warranted in complicated cases of severe pneumonia and in febrile neutropenic patients with normal or nonspecific chest radiographic findings. In patients with normal chest radiographic findings and high clinical suspicion of SARS, CT can be helpful in making the diagnosis.

**Table 1.** Relative radiation level designations

Relative Radiation Level	Effective Dose Estimate Range (mSv)
None	0
Minimal	$<0.1$
Low	0.1–1
Medium	1–10
High	10–100

## 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 indication has been included for each imaging examination. The relative radiation levels 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 (Table 1). Additional information regarding radiation dose assessment for imaging examinations can be found in *ACR Appropriateness Criteria®: Radiation Dose Assessment Introduction* [28].

**Disclaimer:** *The ACR Committee on Appropriateness Criteria® and its expert panels have developed criteria for determining appropriate imaging examinations for the diagnosis and treatment of specified medical conditions. 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 the evaluation of a patient's condition are ranked. Other imaging studies necessary to evaluate other coexistent 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 US Food and Drug Administration have not been considered in developing these criteria, but the 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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