American College of Radiology
ACR Appropriateness Criteria®
Acute Respiratory Illness in Immunocompetent Patients

<u>Variant 1:</u>   **Acute respiratory illness in immunocompetent patients with negative physical examination, normal vital signs, and no other risk factors. Initial imaging.**

Procedure	Appropriateness Category	Relative Radiation Level
Radiography chest	Usually 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	☢☢☢
MRI chest without and with IV contrast	Usually Not Appropriate	O
MRI chest without IV contrast	Usually Not Appropriate	O
US chest	Usually Not Appropriate	O

<u>Variant 2:</u>   **Acute respiratory illnesses in immunocompetent patients with positive physical examination, abnormal vital signs, organic brain disease, or other risk factors. Initial imaging.**

Procedure	Appropriateness Category	Relative Radiation Level
Radiography chest	Usually Appropriate	☢
US chest	May Be Appropriate	O
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	☢☢☢
MRI chest without and with IV contrast	Usually Not Appropriate	O
MRI chest without IV contrast	Usually Not Appropriate	O

<u>Variant 3:</u>   **Acute respiratory illness in immunocompetent patients with positive physical examination, abnormal vital signs, organic brain disease, or other risk factors and negative or equivocal initial chest radiograph. Next imaging study.**

Procedure	Appropriateness Category	Relative Radiation Level
CT chest without IV contrast	Usually Appropriate	☢☢☢
CT chest with IV contrast	May Be Appropriate (Disagreement)	☢☢☢
US chest	May Be Appropriate	O
CT chest without and with IV contrast	Usually Not Appropriate	☢☢☢
MRI chest without and with IV contrast	Usually Not Appropriate	O
MRI chest without IV contrast	Usually Not Appropriate	O

Variant 4: Acute respiratory illnesses in immunocompetent patients with pneumonia complicated by suspected parapneumonic effusion or abscess on initial chest radiograph. Next imaging study.

Procedure	Appropriateness Category	Relative Radiation Level
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)	O
MRI chest without IV contrast	May Be Appropriate (Disagreement)	O
US chest	May Be Appropriate	O
CT chest without and with IV contrast	Usually Not Appropriate	☢☢☢

Variant 5: Acute asthma exacerbation in immunocompetent patients, uncomplicated (no suspicion of pneumonia or pneumothorax). Initial imaging.

Procedure	Appropriateness Category	Relative Radiation Level
Radiography 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	☢☢☢
MRI chest without and with IV contrast	Usually Not Appropriate	O
MRI chest without IV contrast	Usually Not Appropriate	O
US chest	Usually Not Appropriate	O

Variant 6: Acute asthma exacerbation in immunocompetent patients, complicated (suspected pneumonia or pneumothorax). Initial imaging.

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

Variant 7:   **Acute COPD exacerbation in immunocompetent patients, uncomplicated (no chest pain, fever, or leukocytosis, no history of coronary artery disease, or heart failure). Initial imaging.**

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

Variant 8:   **Acute COPD exacerbation in immunocompetent patients with accompanying chest pain, fever, or leukocytosis, or a history of coronary artery disease, or heart failure. 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	☢☢☢
US chest	May Be Appropriate	O
CT chest without and with IV contrast	Usually Not Appropriate	☢☢☢
MRI chest without and with IV contrast	Usually Not Appropriate	O
MRI chest without IV contrast	Usually Not Appropriate	O

ACUTE RESPIRATORY ILLNESS IN IMMUNOCOMPETENT PATIENTS

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Summary of Literature Review

Introduction/Background

Acute respiratory illness (ARI) is defined as one or more of the following symptoms: cough, sputum production, chest pain, or dyspnea (with or without fever), usually in the setting of suspected respiratory infection. ARI is a major public health issue, being one of the most common reasons for doctor office or emergency department (ED) visits. Cough, chest pain, and dyspnea account for 3 of the top 10 presenting symptoms during ED visits [1]. Most cases of ARI are attributable to infection, and the major diagnostic dilemma for patients with ARI is distinguishing patients with self-limited viral infection from those with a bacterial pneumonia (PNA), such as community-acquired PNA. In 2014, PNA (combined with influenza) accounted for the eighth most common cause of death in the United States [2].

The primary role of imaging in patients with ARI is to aid in the diagnosis or exclusion of PNA. By helping to identify the subset of ARI patients with PNA, imaging helps separate patients who would benefit from antibiotic therapy from those who would not. This increases the chance that patients with PNA receive appropriate therapy and reduces the risks associated with inappropriate use of antibiotics in patients with viral causes of ARI. The need for imaging in the ARI patient may depend on a number of factors, which can include severity of illness; presence of fever, leukocytosis, or hypoxemia; clinical history; physical examination findings; patient age; and the presence of other risk factors. Not all studies concur as to which patients with ARI should have an initial imaging study.

ARI in immunocompromised patients is dealt with as a separate topic. The increased risk of morbidity and mortality related to a delay in diagnosis of PNA in this patient population are well documented and warrant a different diagnostic approach. See the ACR Appropriateness Criteria® topic on "Acute Respiratory Illness in Immunocompromised Patients" [3].

Overview of Imaging Modalities

Radiography Chest

The upright posteroanterior and lateral chest radiograph is often considered the gold standard for the diagnosis of PNA; the 2007 consensus guidelines from the Infectious Diseases Society of America/American Thoracic Society (IDSA/ATS) state that "…a demonstrable infiltrate by chest radiograph or other imaging technique…is required for the diagnosis of pneumonia" [4]. The basic concept is that bacteria and neutrophils fill the alveoli, replacing aerated lung and resulting in a pulmonary opacity (formerly called an infiltrate) visible on a chest radiograph as an opacity outlined by aerated lung or silhouetting out normally visualized structures bordering the lung.

While chest radiographs have a long track record, they do have lower sensitivity for PNA relative to other imaging modalities such as CT. Self et al [5] performed an observational cross-sectional multicenter study that enrolled 3,423 ED patients presenting with ARI. This is one of the largest studies comparing chest radiographs and CT in the ED setting. Using CT as a gold standard, chest radiograph test characteristics for detection of pulmonary opacities included: sensitivity of 43.5%, specificity of 93.0%, positive predictive value of 26.9%, and negative predictive value of 96.5%. Conversely, other studies, such as Haga et al [6], demonstrate sensitivities as high as 91% for chest radiographs relative to CT for diagnosing PNA. Despite inconsistent data regarding the

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sensitivity of chest radiographs for PNA, it still plays a role as the primary modality for making or excluding the diagnosis of PNA in patients presenting with ARI.

CT Chest
The major advantage of CT in the setting of ARI is its increased sensitivity relative to chest radiographs for the diagnosis of PNA. In comparative studies in which patients with PNA received both CT and chest radiograph, the rate of PNA missed by chest radiographs but detected by CT has been highly variable, ranging from 9.4% [6] to 56.5% [5]. CT has also been shown to be more specific than chest radiographs for the diagnosis of PNA [5,7].

US Chest
There is a growing body of literature suggesting that bedside lung ultrasound (US) can be a useful tool in the diagnosis and management of PNA [8-12]. Nazerian et al [10] evaluated the accuracy of US relative to CT on 285 patients who had at least one respiratory complaint for which the ED physician ordered a CT. CT was considered positive if at least one typical consolidation was detected. US identified at least one consolidation in 81 patients versus 87 for CT. Relative to CT; US had a sensitivity of 82.8% and a specificity of 95.5%. While this study demonstrates impressive performance of US for detecting pulmonary consolidation, the study was limited by the fact that patients were enrolled based on whether or not they had a CT ordered rather than clinical suspicion of PNA.

US is of limited value in patients with subcutaneous emphysema, in the setting of obesity/thick chest wall, and in patients with limited chest wall access related to bandages, prosthetic material, and skin disorders [13]. In addition, US has difficulty identifying PNAs that are not adjacent to the pleura. This limits its effectiveness for detecting more central infections, especially when there is aerated lung intervening between the transducer and the PNA [8,10,11].

MRI Chest
Our literature search identified one recently published article evaluating the use of MRI in the setting of ARI in immunocompetent adult patients [14]. The study suggests a sensitivity for PNA that approaches that of CT. Over the past 10 years, the utility of MRI for detecting PNA has been studied more extensively in pediatric and immunocompromised patient populations; these studies demonstrated a similar favorable sensitivity of MRI for detecting PNA [15-20].

PET/CT
Our literature search failed to identify any articles published within the past 10 years that justify the use of PET/CT in the initial workup of ARI in the immunocompetent patient. The usefulness of this imaging modality is not discussed in any of the clinical variants because of lack of evidence.

Discussion of Procedures by Variant

Variant 1: Acute respiratory illness in immunocompetent patients with negative physical examination, normal vital signs, and no other risk factors. Initial imaging.

Radiography Chest
As one of the largest studies evaluating the use of chest radiographs in patients with ARI, Benacerraf et al [21] found patient age, physical examination findings, and the presence or absence of hemoptysis to be important factors in determining which patients with ARI had radiographic evidence of PNA. Only 4% (7 of 175) of patients younger than age 40 with symptoms of ARI, a negative physical examination, and no hemoptysis had radiographic findings of PNA. Other studies seem to support the notion that chest radiographs may not be warranted in ARI patients with normal vital signs and negative physical examination findings. For example, in a study of 464 patients with ARI, Heckerling [22] found a low incidence (3%) of PNA in patients with negative physical examinations. Okimoto et al [23] studied 79 outpatients presenting with clinical suspicion of PNA and concluded that radiographs should be ordered only when patients present with fever, cough, sputum production, and coarse crackles on physical examination. O'Brien et al [24] and Ebrahimzadeh et al [25] developed prediction rules for the use of chest radiographs in evaluating for PNA. Both studies concluded that chest radiographs are unnecessary in patients with normal vital signs (pulse, respiratory rate, temperature, and pulse oxygenation) and physical examination findings (normal pulmonary auscultation). However, because approximately 5% of cases would be missed, these criteria are only useful for patients with reliable follow-up and a low likelihood of morbidity if the diagnosis of PNA is delayed.

The presence of underlying comorbid diseases, impaired mucociliary clearance, and waning immunity contributes to the increased incidence of PNA in the elderly [26,27]. In addition, elderly patients with PNA are less likely to report symptoms compared to younger patient cohorts [28]. Given the higher incidence of PNA and risk of mortality in the elderly, advanced age (≥60 years of age) should be considered an additional risk factor for PNA, in which case a lower threshold for chest radiographs may be warranted.

Although Benacerraf et al [21] used an age cutoff of 40 years of age to separate younger low-risk patients from older patients at higher risk for PNA, it should be noted that age 40 was selected somewhat arbitrarily, based on the fact that their data showed a bimodal age distribution of PNAs, with age 40 providing the best separation between populations. Heckerling [22] found that ≥60 years of age had a statistically significant association with PNA on chest radiographs. The CURB-65 PNA severity score uses a cutoff of ≥65 years of age as a risk factor for community-acquired PNA. Given the increased risk of PNA associated with advanced age, an elderly patient with ARI but normal vitals and physical examination findings may still benefit from chest radiographs to exclude PNA.

CT Chest
Our literature search failed to identify any data that suggest that CT serves any significant role in the initial imaging of immunocompetent patients with a low pretest probability of PNA.

US Chest
Many of the studies evaluating the potential of US to diagnose PNA in the ED are aimed at assessing the diagnostic accuracy of US for PNA using either CT or discharge diagnosis as the gold standard [8-11]. Many of these patients were sick enough to warrant CT or admission, representing a subset of patients with a relatively high pretest probability of PNA. The current literature does not suggest a routine role for initial imaging with US in a clinical variant with a low pretest probability of PNA.

MRI Chest
Our literature search failed to identify any data that suggest that MRI serves any significant role in the initial imaging of immunocompetent patients with a low pretest probability of PNA.

Variant 2: Acute respiratory illnesses in immunocompetent patients with positive physical examination, abnormal vital signs, organic brain disease, or other risk factors. Initial imaging.

Radiography Chest
In a series of 300 patients with acute cough illness, Aagaard et al [29] found that a chest radiograph was not always obtained for patients with a high pretest probability of PNA; they infer that when the clinical probability of PNA exceeds a certain level, a negative radiograph would not alter treatment decisions. A series by Basi et al [30] that included 2,706 patients hospitalized with community-acquired PNA similarly showed that about one-third had radiographs initially interpreted as negative for PNA, with minimal change in this interpretation on retrospective review of a random subgroup. These two studies call into question the usefulness of radiographs in patients with a high pretest probability of PNA. That being said, data from many of the studies that suggested the low utility of chest radiographs in Variant 1 also demonstrate a relatively high incidence of PNA on chest radiographs in patients with physical examination findings, abnormal vital signs, leukocytosis, or other risk factors, such as advanced age [21-25].

For example, Benacerraf et al [21] reported that a subgroup of patients <40 years of age with an abnormal physical examination were about six times more likely to have an acute finding on their chest radiograph. Speets et al [31] evaluated 192 patients with a clinical suspicion of PNA by general practitioners and found that the post-test probability of PNA was changed by chest radiographic results in 53% of patients, with a 47% decrease in probability and a 6% increase in probability. Patient management changed following a chest radiograph in 69% of patients. These data would seem to support the routine use of chest radiographs to confirm the diagnosis of PNA in this clinical variant. Current IDSA/ATS guidelines also support this approach [4].

In a population of ED patients who received a chest radiograph for respiratory complaints, Heckerling [22] found that over 75% of the patients with dementia had PNA on their chest radiograph regardless of physical examination findings. The authors postulate that aspiration related to altered level of consciousness and compromised epiglottic closure could account for the high prevalence of PNA amongst these patients. Although there is a paucity of data to support this, it would be logical to include other patients with organic brain disease, such as

stroke and delirium, in addition to dementia, as also having a high pretest probability of PNA despite otherwise negative physical examination findings and normal vital signs.

CT Chest
Our literature search failed to identify any data that suggest that CT serves any significant role in the initial imaging of immunocompetent patients with a high pretest probability of PNA. The role of CT for patients with a negative or equivocal initial chest radiograph is discussed in Variant 3.

US Chest
One prospective multicenter study performed by Reissig et al [11] enrolled 362 patients with abnormal vital signs or physical examination findings in addition to ARI symptoms. Patients received a two-view chest radiograph and a US. In cases in which the chest radiograph was negative or inconclusive and the US was positive, a chest CT was performed. This study demonstrated US sensitivity and specificity of 93.4% and 97.7%, respectively; however, these values are almost certainly overestimated because of the fact that a chest radiograph, rather than CT, was used as the reference standard in all cases except those in which there was discordance between an inconclusive or negative chest radiograph and a positive US. Bourcier et al [8] studied US and chest radiographs in a similar patient population. The final diagnosis was based on a chart review made by an independent expert and included clinical findings, labs, chest radiographs, and CT, if available. US in this study again demonstrated superior sensitivity for PNA relative to chest radiographs. Like Reissig et al, this study was limited by the lack of a consistent end point. Even with these limitations, the results of these studies suggest bedside US can be a useful tool for evaluating certain patients with a high pretest probability of PNA.

MRI Chest
Our literature search failed to identify any data that suggest that MRI serves any significant role in the initial imaging of immunocompetent patients with a high pretest probability of PNA. The role of MRI for patients with a negative or equivocal initial chest radiograph is discussed in Variant 3.

Variant 3: Acute respiratory illness in immunocompetent patients with positive physical examination, abnormal vital signs, organic brain disease, or other risk factors and negative or equivocal initial chest radiograph. Next imaging study.

Radiography Chest
There is no indication in the literature to suggest that repeat chest radiograph serves any significant role in imaging patients with a high pretest probability of PNA and a negative or equivocal initial chest radiograph.

CT Chest
There are several studies that assess the use of CT as a subsequent study in patients who have already had a chest radiograph. One of the larger reviews by Hayden et al [32] identified 97 of 1,057 ED patients with a diagnosis of PNA who had both a chest radiograph and CT. Within this selected group, 26 patients (27%) had PNA that was not detected with chest radiograph but was subsequently detected with CT. Maughan et al [33], in a retrospective review designed to evaluate the false-negative rate of chest radiographs in ED patients with PNA, identified 49 cases (11.4%) where PNA was diagnosed with CT, despite a normal chest radiograph. Haga et al [6] also demonstrated the improved ability of CT to assess the severity of PNA relative to chest radiographs. Bilateral PNA, as detected by CT, was associated with a higher degree of mortality. The presence of multilobar opacities, which is a minor criterion in the IDSA/ATS guidelines for intensive care unit admission, is best assessed with CT [4].

One of the more recent studies assessing the use of CT for ED patients with suspected PNA is Claessens et al [7], a prospective multicenter study that enrolled 319 patients. The inclusion criteria included a mix of ARI symptoms and abnormal vital signs or physical examination findings. All patients received a chest radiograph and a CT within 4 hours of presentation. Chest radiographs identified opacities consistent with PNA in 188 of 319 (59%) patients. CT revealed PNA in 40 (33%) of the 131 patients without opacity on chest radiographs and excluded PNA in 56 (29.8%) of the 188 patients with opacities on chest radiographs. Because of CT, antibiotics were initiated in 51 (16%) patients and discontinued in 29 (9%) patients. CT findings also resulted in 22 additional hospitalizations and 23 discharges.

The available data clearly show that CT is more accurate than chest radiographs for the diagnosis of PNA. In most cases a combination of vital signs and physical examination findings, along with judicious use of chest radiographs, is deemed sufficient for diagnosing or excluding PNA. However, in certain patients, such as those

who cannot reliably follow-up or for whom any delay in diagnosis of PNA could be life-threatening (such as patients with advanced age, unreliable follow-up, or significant comorbidities), chest CT may be warranted when initial chest radiograph is negative or equivocal [24,32,34]. The IDSA/ATS consensus guidelines consider CT a reasonable alternative to empiric antibiotic therapy with follow-up chest radiographs when there is a high clinical suspicion of PNA [4].

Given the difficulty of obtaining an accurate history and physical examination and the high incidence of PNA in patients with organic brain disease, CT is a reasonable alternative to empiric treatment antibiotics in the setting of a negative or equivocal initial chest radiograph.

US Chest
Studies performed by Reissig et al [11] and Bourcier et al [8] suggest that US has a higher sensitivity than radiographs for PNA, implying that US may add value in cases in which PNA is suspected but initial chest radiographs are negative or equivocal. Nazerian et al [10] evaluated the accuracy of US relative to CT on 285 patients who had at least one respiratory complaint for which the ED physician ordered a CT. In the subgroup of patients who also had a chest radiograph, US demonstrated sensitivity and specificity of 81.4% and 94.2%, respectively, versus 64.3% and 90% for chest radiographs. The increased sensitivity of US implies additional value of US in cases in which the initial chest radiograph is discordant with clinical suspicion; however, the study was limited by the fact that patients were enrolled based on whether or not they had a CT ordered, rather than clinical suspicion of PNA.

Given the difficulty of obtaining an accurate history and physical examination as well as the high incidence of PNA in patients with organic brain disease, US is a reasonable alternative to empiric treatment with antibiotics in the setting of a negative or equivocal initial chest radiograph. The ability of the patient to tolerate an US examination, presence of an adequate acoustic window, and the limited ability of US to detect all but peripheral PNAs would be additional considerations.

MRI Chest
Syrjala et al [14] compared the sensitivity and specificity of noncontrast MRI (respiratory-triggered T2 fast spin-echo) to chest radiographs using CT as a gold standard. The patient population consisted of immunocompetent adult ambulatory outpatients with ARI who were febrile and symptomatic for <7 days. CT detected 32 cases of PNA out of 77 prospectively enrolled patients. MRI detected 30/32 cases (sensitivity 94%) with no false-positives (specificity 98%), whereas chest radiographs only detected 23 cases (sensitivity 72%) and gave 4 false-positive results (specificity 91%). These data suggest a potential role for MRI in detecting PNA in situations where initial chest radiographs findings are negative or equivocal; however, the sensitivity of CT appears to be slightly superior to that of MRI.

Variant 4: Acute respiratory illnesses in immunocompetent patients with pneumonia complicated by suspected parapneumonic effusion or abscess on initial chest radiograph. Next imaging study.

Radiography Chest
Chest radiographs are a useful initial imaging modality for complicated PNA, but they are inferior to other modalities for evaluating the pleura, for guiding interventions, or for assessing an opacity that has been refractory to therapy.

CT Chest
In severe cases of PNA, CT can demonstrate the overall extent of disease, which may provide important prognostic information [6]. CT can also demonstrate necrotizing PNA and abscess formation long before the findings become visible on a chest radiograph. The use of intravenous contrast can increase the conspicuity of empyemas and other pleural complications. CT can also serve as a guide for pleural drainage or localization of an appropriate site for biopsy [35]. CT is the modality of choice for evaluating a persistent opacity. Its superior contrast resolution allows it to detect obstructing masses, delineate lesions, such as sequestrations, and even characterize patterns of parenchymal disease, such that a particular etiology, such as organizing PNA or mycobacterial infection, can sometimes be suggested.

US Chest
US may be a useful adjunct for the evaluation of parapneumonic effusions as it is superior to chest radiographs for demonstrating pleural thickening and adhesions. US is superior to noncontrast CT for detecting septations in

complex effusions. US can also be used to guide PNA-related interventions, such as biopsy, thoracentesis, and thoracostomy tube placement [36].

MRI Chest
Our search failed to identify any studies evaluating the role of MRI in this clinical scenario. The study population examined by Syrjala et al [14] did not include any patients with parapneumonic effusion or empyema. However, MRI has been shown to be at least as sensitive as CT for detecting pleural effusions in immunocompromised patients and is superior to CT for detecting pleural adhesions/loculations [16].

Variant 5: Acute asthma exacerbation in immunocompetent patients, uncomplicated (no suspicion of pneumonia or pneumothorax). Initial imaging.

Radiography Chest
The incidence of PNA is exceedingly low in patients presenting with an uncomplicated asthma exacerbation. Heckerling [22] reported <2% of asthmatic patients as having pneumonic opacities. Findley and Sahn [37] observed that 99% of their patients either had normal chest radiograph examinations or showed only slightly prominent markings or hyperinflation.

CT Chest
Our literature search failed to identify any data that suggest that CT serves any significant role in the initial imaging of immunocompetent patients with a low pretest probability of PNA presenting with an acute asthma exacerbation.

US Chest
Our literature search failed to identify any data that suggest that US serves any significant role in the initial imaging of immunocompetent patients with a low pretest probability of PNA presenting with an acute asthma exacerbation.

MRI Chest
Our literature search failed to identify any data that suggest that MRI serves any significant role in the initial imaging of immunocompetent patients with a low pretest probability of PNA presenting with an acute asthma exacerbation.

Variant 6: Acute asthma exacerbation in immunocompetent patients, complicated (suspected pneumonia or pneumothorax). Initial imaging.

Radiography Chest
Use of chest radiographs in patients with asthma exacerbation is controversial. Petheram et al [38] found clinically important radiographic findings in 9% of their patients and concluded that a chest radiograph is indicated. However, the incidence of PNA in patients presenting with an asthma exacerbation is low [22,37]. Findley and Sahn [37] recommended chest radiographs only when PNA or pneumothorax is suspected. White et al [39] found significant chest radiograph abnormalities in 34% of adults whose asthma exacerbation warranted hospital admission.

CT Chest
Although our literature search failed to identify any data that suggest that CT serves any significant role in the initial imaging of patients with a high pretest probability of PNA presenting with an acute asthma exacerbation, patients who cannot reliably follow-up or for whom any delay in diagnosis of PNA could be life-threatening may warrant a CT if the chest radiograph is negative or equivocal. Chest radiographs are usually sufficient to diagnose pneumothorax. CT should be reserved for patients who require additional evaluation of their pneumothorax to look for an underlying cause.

US Chest
US may be a reasonable alternative to chest radiographs to identify PNA [8-12] and pneumothorax [13].

MRI Chest
Our literature search failed to identify any data that suggest that MRI serves any significant role in the initial imaging of immunocompetent patients with a high pretest probability of PNA presenting with an acute asthma exacerbation.

Variant 7: Acute COPD exacerbation in immunocompetent patients, uncomplicated (no chest pain, fever, or leukocytosis, no history of coronary artery disease, or heart failure). Initial imaging.

Radiography Chest

The ATS defines a chronic obstructive pulmonary disease (COPD) flare as an acute worsening of COPD symptoms. Sherman et al [40] studied the usefulness of chest radiographs in 242 patients with acute exacerbations of COPD. Of this group, 135 patients (56%) had asthma, and 107 (44%) had emphysema and chronic bronchitis. Chest radiographs were abnormal in 14% but resulted in significant change in management in only 4.5%.

CT Chest

Our literature search failed to identify any data that suggest that CT serves any significant role in the initial imaging of immunocompetent patients with a low pretest probability of PNA presenting with a COPD exacerbation.

US Chest

Our literature search failed to identify any data that suggest that US serves any significant role in the initial imaging of immunocompetent patients with a low pretest probability of PNA presenting with a COPD exacerbation.

MRI Chest

Our literature search failed to identify any data that suggest that MRI serves any significant role in the initial imaging of immunocompetent patients with a low pretest probability of PNA presenting with a COPD exacerbation.

Variant 8: Acute COPD exacerbation in immunocompetent patients with accompanying chest pain, fever, or leukocytosis, or a history of coronary artery disease, or heart failure. Initial imaging.

Radiography Chest

Chest radiographs seem warranted in COPD patients with significant comorbidities or a higher pretest probability of PNA (such as those who are elderly or who have abnormal vital signs or physical examination findings). Sherman et al [40] suggested that a chest radiograph is indicated if a COPD exacerbation is accompanied by leukocytosis, chest pain, or edema, or by a history of coronary artery disease or congestive heart failure.

CT Chest

Certain patients who cannot reliably follow-up or for whom any delay in diagnosis of PNA could be life-threatening may warrant CT when the chest radiograph is negative or equivocal. In patients with significant underlying emphysema, widespread alveolar destruction can result in more subtle, interstitial manifestations on imaging ("Swiss cheese" PNA). In these cases, the added sensitivity of CT may help confirm the diagnosis.

US Chest

Studies by Reissig et al [11] and Nazerian et al [10] included patients with COPD. There was no mention of how the presence of COPD might affect the ability of US to diagnose PNA. The presence of COPD did not appear to be a contraindication to US.

MRI Chest

Our literature search failed to identify any data that suggest that MRI serves any significant role in the initial imaging of immunocompetent patients with a high pretest probability of PNA presenting with a COPD exacerbation.

Summary of Recommendations

- **Variant 1:** A chest radiograph is usually appropriate for the initial imaging of immunocompetent patients presenting with ARI and a negative physical examination, normal vital signs, and no other risk factors.
- **Variant 2:** A chest radiograph is usually appropriate for the initial imaging of immunocompetent patients presenting with ARI and positive physical examination, abnormal vital signs, organic brain disease, or other risk factors.
- **Variant 3:** Chest CT without IV contrast is usually appropriate for imaging immunocompetent patients with ARI and positive physical examination, abnormal vital signs, organic brain disease or other risk factors and a negative or equivocal initial chest radiograph.

- **Variant 4:** Chest CT, with or without IV contrast, is usually appropriate for imaging immunocompetent patients with PNA complicated by suspected parapneumonic effusion or abscess on initial chest radiograph and MRI may be appropriate in this scenario.
- **Variant 5:** Imaging is usually not appropriate for the initial workup of immunocompetent patients presenting with an uncomplicated acute asthma exacerbation (no suspicion of PNA or pneumothorax) but a chest radiograph may be appropriate.
- **Variant 6:** A chest radiograph is usually appropriate for the initial imaging of immunocompetent patients presenting with a complicated acute asthma exacerbation (suspected PNA or pneumothorax).
- **Variant 7:** A chest radiograph is usually appropriate for the initial imaging of an uncomplicated acute COPD exacerbation in immunocompetent patients (no chest pain, fever, or leukocytosis, no history of coronary artery disease, or heart failure).
- **Variant 8:** A chest radiograph is usually appropriate for the initial imaging of complicated acute COPD exacerbation in immunocompetent patients (chest pain, fever, leukocytosis, or a history of coronary artery disease, or heart failure).

Summary of Evidence

Of the 41 references cited in the *ACR Appropriateness Criteria® Acute Respiratory Illness in Immunocompetent Patients* document, 1 is categorized as well-designed therapeutic reference Additionally, 40 references are categorized as diagnostic references including 2 well-designed studies, 9 good-quality studies, and 9 quality studies that may have design limitations. There are 20 references that may not be useful as primary evidence.

The 41 references cited in the ACR Appropriateness Criteria® *Acute Respiratory Illness in Immunocompetent Patients* document were published from 1980 to 2017.

Although there are references that report on studies with design limitations, 12 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 [41].

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.

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