American College of Radiology
ACR Appropriateness Criteria®

Acute Respiratory Illness in Immunocompetent Patients

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

Procedure	Appropriateness Category	Relative Radiation Level
Radiography chest	May Be Appropriate (Disagreement)	☢
US chest	Usually Not Appropriate	O
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	☢☢☢
CT chest without IV contrast	Usually Not Appropriate	☢☢☢
CTA chest with IV contrast	Usually Not Appropriate	☢☢☢
V/Q scan lung	Usually Not Appropriate	☢☢☢

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

Procedure	Appropriateness Category	Relative Radiation Level
Radiography chest	Usually Appropriate	☢
US chest	Usually Not Appropriate	O
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	☢☢☢
CT chest without IV contrast	Usually Not Appropriate	☢☢☢
CTA chest with IV contrast	Usually Not Appropriate	☢☢☢
V/Q scan lung	Usually Not Appropriate	☢☢☢

Variant: 3 Adult. Acute respiratory illness in immunocompetent patients with positive physical examination, abnormal vital signs, organic brain disease, or other risk factors and negative or indeterminate 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	☢☢☢
CTA chest with IV contrast	May Be Appropriate	☢☢☢
US chest	Usually Not Appropriate	O
MRI chest without and with IV contrast	Usually Not Appropriate	O
MRI chest without IV contrast	Usually Not Appropriate	O
CT chest without and with IV contrast	Usually Not Appropriate	☢☢☢
V/Q scan lung	Usually Not Appropriate	☢☢☢

Variant: 4 **Adult. Acute respiratory illness 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	☢☢☢
US chest	May Be Appropriate	O
MRI chest without and with IV contrast	Usually Not Appropriate	O
MRI chest without IV contrast	Usually Not Appropriate	O
CT chest without and with IV contrast	Usually Not Appropriate	☢☢☢
CTA chest with IV contrast	Usually Not Appropriate	☢☢☢
V/Q scan lung	Usually Not Appropriate	☢☢☢

Variant: 5 **Adult. Acute asthma exacerbation in immunocompetent patients, uncomplicated. Initial imaging.**

Procedure	Appropriateness Category	Relative Radiation Level
Radiography chest	May Be Appropriate	☢
US chest	Usually Not Appropriate	O
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	☢☢☢
CT chest without IV contrast	Usually Not Appropriate	☢☢☢
CTA chest with IV contrast	Usually Not Appropriate	☢☢☢
V/Q scan lung	Usually Not Appropriate	☢☢☢

Variant: 6 **Adult. Acute asthma exacerbation in immunocompetent patients, complicated. Initial imaging.**

Procedure	Appropriateness Category	Relative Radiation Level
Radiography chest	Usually Appropriate	☢
US chest	Usually Not Appropriate	O
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	☢☢☢
CT chest without IV contrast	Usually Not Appropriate	☢☢☢
CTA chest with IV contrast	Usually Not Appropriate	☢☢☢
V/Q scan lung	Usually Not Appropriate	☢☢☢

Variant: 7 **Adult. Acute COPD exacerbation in immunocompetent patients, uncomplicated. Initial imaging.**

Procedure	Appropriateness Category	Relative Radiation Level
Radiography chest	Usually Appropriate	☢
US chest	Usually Not Appropriate	O

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	☢☢☢
CT chest without IV contrast	Usually Not Appropriate	☢☢☢
CTA chest with IV contrast	Usually Not Appropriate	☢☢☢
V/Q scan lung	Usually Not Appropriate	☢☢☢

Variant: 8 Adult. Acute COPD exacerbation in immunocompetent patients with accompanying chest pain, or 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	☢
CTA chest with IV contrast	May Be Appropriate	☢☢☢
US chest	Usually Not Appropriate	O
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	☢☢☢
CT chest without IV contrast	Usually Not Appropriate	☢☢☢
V/Q scan lung	Usually Not Appropriate	☢☢☢

Variant: 9 Adult. Acute respiratory illness in immunocompetent patients with suspected pneumonia on initial imaging. Follow-up imaging to ensure resolution.

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	Usually Not Appropriate	O
MRI chest without and with IV contrast	Usually Not Appropriate	O
MRI chest without IV contrast	Usually Not Appropriate	O
CT chest without and with IV contrast	Usually Not Appropriate	☢☢☢
CTA chest with IV contrast	Usually Not Appropriate	☢☢☢
V/Q scan lung	Usually Not Appropriate	☢☢☢

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Summary of Literature Review

Introduction/Background

Acute respiratory illness (ARI) is defined as 1 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 1 of the most common reasons for medical office or emergency department (ED) visits. Cough, chest pain, and dyspnea account for 3 of the top 10 presenting symptoms during ED visits [1]. The majority of ARIs stem from infections. A significant challenge in diagnosing ARI lies in discerning between self-limited viral pneumonias (PNAs), common in ARI cases, and more severe conditions like community-acquired pneumonia (CAP). CAP demands specific treatments tailored for bacterial PNA or atypical PNA, including those that result from certain viral infections such as influenza and COVID-19. In early 2020, the World Health Organization (WHO) officially declared COVID-19 a pandemic, presenting an unprecedented challenge to global health care systems. Despite the formal end of the pandemic declaration, the emergence of new variants persists, with ongoing worldwide impact. Throughout this ongoing crisis, chest imaging remains indispensable in the management of COVID-19 PNA, as elaborated below. In 2020, PNA due to COVID-19 accounted for the third and influenza accounted for the eighth most common causes of death in the United States, respectively [2].

The primary role of imaging in patients with ARI is to aid in the diagnosis or exclusion of PNA. Other conditions such as venous thromboembolic disease, pulmonary edema, and pneumothorax among others can also result in ARI in patients presenting with dyspnea, chest pain, or both. Imaging for these suspected conditions is covered in detail in the ACR Appropriateness Criteria® topics on "Routine Chest Imaging" [3], "Suspected Pulmonary Embolism" [4], "Chronic Chest Pain-High Probability of Coronary Artery Disease" [5], "Dyspnea-Suspected Cardiac Origin (Ischemia Already Excluded)" [6] and "Chronic Dyspnea-Noncardiovascular Origin" [7].

By helping to identify the subset of patients with ARI and PNA, imaging helps to separate patients who would benefit from treatments that include antibiotics, antifungal and antiviral therapies from those who would not. This increases the likelihood that patients with PNA will receive appropriate therapy and reduces the risks associated with inappropriate use of antibiotics in patients with viral causes of ARI, which may be self-limiting or require specific antiviral or anti-inflammatory treatments. The need for imaging in the patient with ARI 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. Severity of disease in COVID-19 illness depends on age, underlying medical conditions, immune status, variant type, and vaccination status. Imaging also provides a platform for monitoring of progressive disease burden and can identify complications of PNA that can manifest in the presence of comorbidities like diabetes, hypertension, heart disease, and risk factors like older age and obesity.

Not all studies concur as to which patients with ARI should undergo imaging. A multinational consensus statement from the Fleischner Society does not endorse imaging for patients with suspected COVID-19 and mild clinical symptoms unless there is a risk of progression of disease or if respiratory status worsens. If the pretest probability of COVID-19 PNA is high with clinical features of moderate to high severity, imaging may be used to triage patients based on the resources available.

ARI in immunocompromised patients is discussed 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" [8].

Special Imaging Considerations

Point-of-care ultrasound (POCUS) at bedside has been explored in health care settings of ED, intensive care units, and settings in which access to CT is limited either due to a need of rapid assessment or a critical condition that limits patient mobility and transportation to the radiology suite. POCUS is performed by trained personnel and offers assessment of lung, heart, and potential venous thromboembolism. POCUS allows clinicians to directly assess for signs of consolidations and pleural effusions in real time [9]. POCUS examinations focus on qualitative and semiquantitative assessment of the regions of interest based on the result of history and physical examination and can also be used to guide procedures and for monitoring purpose [9]. However, the ultrasound (US) examination described in the variants below refers to the modality as performed by the radiology personnel in the radiology department and not as POCUS.

Initial Imaging Definition

Initial imaging is defined as imaging at the beginning of the care episode for the medical condition defined by the variant. More than one procedure can be considered usually appropriate in the initial imaging evaluation when:

- There are procedures that are equivalent alternatives (i.e., only one procedure will be ordered to provide the clinical information to effectively manage the patient's care)

OR

- There are complementary procedures (i.e., 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).

Discussion of Procedures by Variant

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

The diagnosis of CAP relies on identifying clinical symptoms such as cough, fever, dyspnea, sputum production, and pleuritic chest pain, often supplemented by laboratory findings like leukocytosis in bacterial PNA, and supported by chest imaging, typically chest radiography. Some studies have concluded that chest radiographs are unnecessary in patients with normal vital signs (eg, pulse, respiratory rate, temperature, and pulse oxygenation) and physical examination findings (normal pulmonary auscultation) [10,11]. 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. Imaging is not indicated as a screening test for COVID-19 in asymptomatic individuals or for patients with clinical features of mild severity because the yield in these settings is very low and for most patients self-monitoring for clinical worsening is feasible and safe [12].

Variant 1: Adult. Acute respiratory illness in immunocompetent patients with negative

physical examination, normal vital signs, and no other risk factors for poor outcome. Initial imaging.
A. CT chest with IV contrast

There is no relevant literature to support the use of CT chest with intravenous (IV) contrast in the initial imaging of immunocompetent patients with a low pretest probability of PNA.

Variant 1: Adult. Acute respiratory illness in immunocompetent patients with negative physical examination, normal vital signs, and no other risk factors for poor outcome. Initial imaging.
B. CT chest without and with IV contrast

There is no relevant literature to support the use of CT chest without and with IV contrast in the initial imaging of immunocompetent patients with a low pretest probability of PNA.

Variant 1: Adult. Acute respiratory illness in immunocompetent patients with negative physical examination, normal vital signs, and no other risk factors for poor outcome. Initial imaging.
C. CT chest without IV contrast

There is no relevant literature to support the use of CT chest without IV contrast in the initial imaging of immunocompetent patients with a low pretest probability of PNA.

Variant 1: Adult. Acute respiratory illness in immunocompetent patients with negative physical examination, normal vital signs, and no other risk factors for poor outcome. Initial imaging.
D. CTA chest with IV contrast

There is no relevant literature to support the use of CTA chest with IV contrast in the initial imaging of immunocompetent patients with a low pretest probability of PNA.

Variant 1: Adult. Acute respiratory illness in immunocompetent patients with negative physical examination, normal vital signs, and no other risk factors for poor outcome. Initial imaging.
E. MRI chest without and with IV contrast

There is no relevant literature to support the use of MRI chest without and with IV contrast in the initial imaging of immunocompetent patients with a low pretest probability of PNA.

Variant 1: Adult. Acute respiratory illness in immunocompetent patients with negative physical examination, normal vital signs, and no other risk factors for poor outcome. Initial imaging.
F. MRI chest without IV contrast

There is no relevant literature to support the use of MRI chest without IV contrast in the initial imaging of immunocompetent patients with a low pretest probability of PNA.

Variant 1: Adult. Acute respiratory illness in immunocompetent patients with negative physical examination, normal vital signs, and no other risk factors for poor outcome. Initial imaging.
G. Radiography chest

With 1 of the largest studies evaluating the use of chest radiographs in patients with ARI, Benacerraf et al [13] 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 <40 years of age 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 patients with ARI with normal vital signs and negative physical examination findings. For example, in a study of 464 patients with ARI, Heckerling [14] found a low incidence (3%) of PNA in patients with negative physical examinations. Okimoto et al [15] 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 [11] and Ebrahimzadeh et al [10] developed prediction rules for the use of chest radiographs in evaluating for PNA.

Although Benacerraf et al [13] used a 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 40 years of age was selected somewhat arbitrarily, based on the fact that their data showed a bimodal age distribution of PNAs, with 40 years of age providing the best separation between populations. Heckerling [14] found that age ≥60 years 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 CAP. Given the increased risk of PNA associated with advanced age, an elderly patient with ARI but normal vital signs and physical examination findings may still benefit from chest radiographs to exclude PNA. The upright posteroanterior (PA) and lateral chest radiograph is often considered the reference standard for the diagnosis of PNA and is typically higher quality and preferred over anterior-posterior (AP) portable radiography, when feasible [16-18].

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

H. US chest

Many of the studies evaluating the potential of US to diagnose PNA in the ED assess the diagnostic accuracy of US for PNA using either CT or discharge diagnosis as the reference standard [19-22]. 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 support initial imaging with US chest of immunocompetent patients with a low pretest probability of PNA.

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

I. V/Q scan lung

There is no relevant literature to support the use of ventilation-perfusion (V/Q) lung scan in the initial imaging of immunocompetent patients with a low pretest probability of PNA.

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

The diagnosis of CAP relies on identifying clinical symptoms such as cough, fever, dyspnea, sputum production, and pleuritic chest pain, often supplemented by laboratory findings like leukocytosis in bacterial PNA, elevated procalcitonin, or C-reactive protein and supported by chest imaging, typically with chest radiography. The upright PA and lateral chest radiograph is often considered the reference standard for the diagnosis of PNA and is typically higher quality and preferred over AP portable radiography, when feasible [16,17]. Although crackles and rhonchi are significant

aspects of physical assessment, they lack the sensitivity and specificity of chest radiographs [23]. A chest radiograph serves not only for PNA diagnosis but also for monitoring disease progression and assessing medical support devices in critically ill patients. The portability of radiography equipment helps to reduce the risk of cross-infection. Despite inconsistent data regarding the sensitivity of chest radiography for PNA, it still plays a role as the primary modality for making or excluding the diagnosis of PNA in patients presenting with ARI.

The presence of underlying comorbid diseases, impaired mucociliary clearance, and waning immunity contributes to the increased incidence of PNA in the elderly [24,25]. In addition, elderly patients with PNA are less likely to report symptoms compared to younger patient cohorts [26]. 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.

Variant 2: Adult. Acute respiratory illness in immunocompetent patients with positive physical examination, or abnormal vital signs, or organic brain disease, or other risk factors for poor outcome. Initial imaging.
A. CT chest with IV contrast

There is no relevant literature to support the use of CT chest with IV contrast in the initial imaging of immunocompetent patients with a high pretest probability of PNA. In patients with suspected COVID-19 in whom imaging of the chest is indicated, the preference of modality of radiography versus CT depends on the policy of the local radiology department. CT should be reserved for hospitalized, symptomatic patients with high risk factors, increased comorbidities and suspected complications.

Variant 2: Adult. Acute respiratory illness in immunocompetent patients with positive physical examination, or abnormal vital signs, or organic brain disease, or other risk factors for poor outcome. Initial imaging.
B. CT chest without and with IV contrast

There is no relevant literature to support the use of CT chest with IV contrast in the initial imaging of immunocompetent patients with a high pretest probability of PNA. In patients with suspected COVID-19 in whom imaging of the chest is indicated, the preference of modality of radiography versus CT depends on the policy of the local radiology department. CT should be reserved for hospitalized, symptomatic patients with high risk factors, increased comorbidities and suspected complications.

Variant 2: Adult. Acute respiratory illness in immunocompetent patients with positive physical examination, or abnormal vital signs, or organic brain disease, or other risk factors for poor outcome. Initial imaging.
C. CT chest without IV contrast

There is no relevant literature to support the use of CT chest without IV contrast in the initial imaging of immunocompetent patients with a high pretest probability of PNA. In patients with suspected COVID-19 in whom imaging of the chest is indicated, the preference of modality of radiography versus CT depends on the policy of the local radiology department.

Variant 2: Adult. Acute respiratory illness in immunocompetent patients with positive physical examination, or abnormal vital signs, or organic brain disease, or other risk factors for poor outcome. Initial imaging.
D. CTA chest with IV contrast

There is no relevant literature to support the use of CT angiography (CTA) with IV contrast in the initial imaging of immunocompetent patients with a high pretest probability of PNA. In patients with suspected COVID-19 in whom imaging of the chest is indicated for evaluation of pulmonary embolism, CTA, may be used depending on the clinical symptoms and lab values. Otherwise, the preference of modality of radiography versus CT depends on the policy of the local radiology department. CT should be reserved for hospitalized, symptomatic patients with high risk factors, increased comorbidities and suspected complications.

Variant 2: Adult. Acute respiratory illness in immunocompetent patients with positive physical examination, or abnormal vital signs, or organic brain disease, or other risk factors for poor outcome. Initial imaging.
E. MRI chest without and with IV contrast

There is no relevant literature to support the use of MRI chest without and with IV contrast in the initial imaging of immunocompetent patients with a high pretest probability of PNA.

Variant 2: Adult. Acute respiratory illness in immunocompetent patients with positive physical examination, or abnormal vital signs, or organic brain disease, or other risk factors for poor outcome. Initial imaging.
F. MRI chest without IV contrast

There is no relevant literature to support the use of MRI chest without IV contrast in the initial imaging of immunocompetent patients with a high pretest probability of PNA.

Variant 2: Adult. Acute respiratory illness in immunocompetent patients with positive physical examination, or abnormal vital signs, or organic brain disease, or other risk factors for poor outcome. Initial imaging.
G. Radiography chest

In a series of 300 patients with an ARI, Aagaard et al [27] observed that a chest radiograph was not consistently obtained for individuals with a high pretest probability of PNA. They concluded that when the clinical probability of PNA reaches a certain threshold, a negative radiograph would not influence treatment decisions. A series by Basi et al [28] included 2,706 patients hospitalized with CAP and 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 2 studies call into question the usefulness of radiographs in patients with a high pretest probability of PNA. However, data from many of the studies that suggested the low usefulness 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 [10,11,13-15].

For example, Benacerraf et al [13] reported that a subgroup of patients <40 years of age with an abnormal physical examination were approximately 6 times more likely to have an acute finding on their chest radiograph. Speets et al [29] evaluated 192 patients with a clinical suspicion of PNA by general practitioners and found that the posttest 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. This data would seem to support the routine use of chest radiographs to confirm the diagnosis of PNA in this clinical variant. Current Infectious Disease Society of America/American Thoracic Society (IDSA/ATSuidelines also support this approach [16] using chest radiography as an imaging tool in the diagnosis of CAP in addition to lab values in patients with high index of suspicion for CAP.

In a population of ED patients who received a chest radiograph forrespiratory complaints, Heckerling [14] found that more than 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, because also having a high pretest probability of PNA despite otherwise negative physical examination findings and normal vital signs.

Both clinical features and physical examination findings of CAP may be lacking or altered in elderly patients. A chest radiograph is useful to not only establish the diagnosis and to aid in differentiating CAP from other common causes of cough and fever, such as acute bronchitis, but may suggest a broad category of etiologic agent, prognosis, alternative diagnosis, and associated complications or conditions.

Radiographs serve as valuable tools in identifying PNA complications such as abscesses and parapneumonic effusions. However, positioning of the patient can impact effusion detection. Therefore, both PA and lateral radiography are recommended as the initial imaging choices for patients with suspected PNA to detect parapneumonic effusions, because they are superior over AP chest radiography [18].

According to WHO guidelines, for symptomatic patients suspected of having COVID-19, chest imaging should be used when reverse transcriptase-polymerase chain reaction (RT-PCR) testing results are delayed or initial test is negative but a high clinical suspicion remains for COVID-19. Imaging can be useful in patients with moderate to severe symptoms, or suspected complications of COVID-19, like bacterial PNA, pulmonary arterial thrombosis, or thromboembolism.
Chest radiography may also assist in risk stratification for development of severe disease and predict the need for hospitalization and intubation. The specificity and positive predictive value of radiographic findings for COVID-19 PNA depend on the overall prevalence of disease. The sensitivity of chest radiography for the detection of COVID-19 infection is 69% to 75%, with a lower sensitivity earlier in the course of disease, because the severity of imaging findings peak at about 10 to 12 days from onset of symptoms [30].

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

H. US chest

One prospective multicenter study performed by Reissig et al [22] enrolled 362 patients with abnormal vital signs or physical examination findings in addition to ARI symptoms. Patients received a 2-view chest radiograph and 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 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 [19] 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, laboratory tests, chest radiographs, and CT, if

available. US in this study again demonstrated superior sensitivity for PNA relative to chest radiographs. Like the study of 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.

In a recent study by Tana et al [31], a strong positive linear correlation between lung US (LUS) and CT scores (Pearson correlation ^{r} = 0.754; R^2 = 0.568; *I* < .001) was observed. The optimal cut-point for mortality prediction was 20 for LUS score and 4.5 for chest CT score, because the in-hospital mortality significantly increased among COVID-19 patients presenting with an LUS score ≥20 (log-rank 0.003; hazard ratio [HR] 9.87, 95% confidence interval [CI], 2.22-43.83) or a chest CT score ≥4.5 (HR 4.34, 95% CI, 0.97-19.41). Despite this data, US chest is usually not indicated in the initial imaging of immunocompetent patients with a high pretest probability of PNA.

Variant 2: Adult. Acute respiratory illness in immunocompetent patients with positive physical examination, or abnormal vital signs, or organic brain disease, or other risk factors for poor outcome. Initial imaging.
I. V/Q scan lung

There is no relevant literature to support the use of V/Q scan lung in the initial imaging of immunocompetent patients with a high pretest probability of PNA.

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

Chest radiographs have a lower sensitivity for PNA relative to other imaging modalities such as CT. 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, for certain patients, such as those who cannot reliably follow-up or for whom a delay in diagnosis of PNA could be life-threatening (such as patients with advanced age or significant comorbidities), chest CT may be warranted when initial imaging is negative or indeterminate [11,32,33].

The major advantage of CT in the setting of ARI is its increased sensitivity relative to chest radiographs for the diagnosis of PNA [34]. CT is also of value in characterizing complications including empyema or diffuse alveolar damage, detecting pulmonary thromboembolism on contrast-enhanced CT, and suggesting alternative diagnoses, like aspiration PNA or pulmonary edema. Administration of IV contrast remains at the discretion of the radiologist in the above studies and may be useful in certain situations such as suspected pulmonary abscess or empyema or pulmonary thromboembolism.

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

Chest radiography has a lower sensitivity and specificity for PNA detection when compared with CT [30,31]. In comparative studies in which patients with PNA received both a CT and chest radiographs, the rate of PNA missed by chest radiographs but detected by CT has been highly variable, ranging from 9.4% [35] to 56.5% [34]. Chest CT has a higher sensitivity than chest radiography for the detection of COVID-19 PNA and can be useful in patients with some prior pulmonary diseases, but the reported specificity of CT for detection of COVID-19 PNA is variable

and ranges from 7% to 100% [12,30]. A variable prevalence of other diseases including influenza (eg, H1N1), severe acute respiratory syndrome (SARS), and middle east respiratory syndrome (MERS) have features that overlap with COVID-19, limiting its specificity. Chest CT with IV contrast allows for better evaluation of pleural thickening in empyema and in the identification of a necrotic component in lung abscess and necrotizing PNA [36]. Heterogeneous enhancement of consolidations and necrotic mediastinal and hilar lymph nodes are also better visualized with IV contrast. In patients with hemoptysis, IV contrast allows better delineation of vascular involvement like Rasmussen aneurysms in tuberculosis and vascular invasion in fungal diseases.

Self et al [34] performed an observational cross-sectional multicenter study that enrolled 3,423 ED patients presenting with ARI. Using CT as a reference standard, chest radiograph test characteristics for the detection of pulmonary opacities included a 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 that of Haga et al [35], demonstrate sensitivities as high as 91% for chest radiographs relative to CT for diagnosing PNA.

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 [37], in a retrospective review designed to evaluate the false-negative rate of chest radiographs in ED patients with PNA, identified 49 cases (11.4%) in which PNA was diagnosed with CT, despite a normal chest radiograph. Haga et al [35] 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. CT is more sensitive in detecting multilobar opacities, which is a minor criterion in the IDSA/ATS guidelines for intensive care unit admission, although implications on prognosis in CAP have also been shown using chest radiographs [16,38,39].

One of the more recent studies assessing the use of CT for ED patients with suspected PNA is that of Claessens et al [40], 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. 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 [16].

For COVID-19 infection, the choice of imaging modality should depend on clinical teams' decision. Chest CT may be negative in the early phase of the disease and the positivity of the scan may vary with the duration of the illness. According to WHO guidelines, for symptomatic patients suspected

of having COVID-19, chest imaging should be used, when RT-PCR testing is not available, or results are delayed or initial test is negative, but a high clinical suspicion remains for COVID-19. Imaging can be useful in patients with moderate to severe symptoms or suspected complications of COVID-19, like PNA, pulmonary arterial thrombosis, or pulmonary thromboembolism.

The WHO guideline committee evaluated the studies for diagnostic accuracy of 3 imaging modalities, chest radiography (n = 3), chest CT (n = 19), and LUS (n = 1), in patients with clinical features suspected of having COVID-19, against a reference standard. The median sensitivity and specificity reported by the included studies were 64% and 82% for chest radiography, 92% and 56% for chest CT, and 95% and 83% for LUS [12]. The studies did not compare any 2 imaging modalities against each other, and a systematic review identified biases and shortcomings of several studies.

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 antibiotics in the setting of a negative or indeterminate chest radiograph [8].

Variant 3: Adult. Acute respiratory illness in immunocompetent patients with positive physical examination or abnormal vital signs or organic brain disease or other risk factors and negative or indeterminate initial chest radiograph. Next imaging study.
B. CT chest without and with IV contrast

Performing CT chest without and with IV contrast does not have added value compared to CT chest with IV contrast or CT chest without IV contrast in the evaluation of immunocompetent patients with a high pretest probability of PNA and a negative or indeterminate initial chest radiograph.

Variant 3: Adult. Acute respiratory illness in immunocompetent patients with positive physical examination or abnormal vital signs or organic brain disease or other risk factors and negative or indeterminate initial chest radiograph. Next imaging study.
C. CT chest without IV contrast

Chest radiography has a lower sensitivity and specificity for PNA detection when compared with CT [30,31]. In comparative studies in which patients with PNA received both a CT and chest radiographs, the rate of PNA missed by chest radiographs but detected by CT has been highly variable, ranging from 9.4% [35] to 56.5% [34]. Chest CT has a higher sensitivity than chest radiography for the detection of COVID-19 PNA and can be useful in patients with some prior pulmonary diseases, but the reported specificity of CT for the detection of COVID-19 PNA is variable and ranges from 7% to 100% [12,30]. A variable prevalence of other diseases including influenza (eg, H1N1), SARS, and MERS have features that overlap with COVID-19, limiting its specificity.

Self et al [34] performed an observational cross-sectional multicenter study that enrolled 3,423 ED patients presenting with ARI. Using CT as a reference standard, chest radiograph test characteristics for the detection of pulmonary opacities included a 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 by Haga et al [35], demonstrate sensitivities as high as 91% for chest radiographs relative to CT for diagnosing PNA.

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 [37], in a retrospective review designed to evaluate the false-negative rate of chest radiographs in ED patients with PNA, identified 49 cases (11.4%) in which PNA was diagnosed with CT, despite a normal chest radiograph. Haga et al [35] 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 [16].

One of the more recent studies assessing the use of CT for ED patients with suspected PNA is by Claessens et al [40], 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.

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 [16].
For COVID-19 infection, the choice of imaging modality should depend on the local resources, expertise, and clinical teams' decision. The chest CT may be negative in the early phase of the disease, and the positivity of the scan may vary with the duration of the illness.

The WHO guideline committee evaluated the studies for diagnostic accuracy of 3 imaging modalities, chest radiography (n = 3), chest CT (n = 19), and LUS (n = 1), in patients with clinical features suspected of having COVID-19, against a reference standard. The median sensitivity and specificity reported by the included studies were 64% and 82% for chest radiography, 92% and 56% for chest CT, and 95% and 83% for LUS [12]. The studies did not compare any 2 imaging modalities against each other, and a systematic review identified the studies to be suffering from biases and shortcomings.

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 indeterminate initial chest radiograph.

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

CTA chest with IV contrast may be used to identify pulmonary arterial thrombosis or pulmonary thromboembolism if there is a high suspicion of the same in addition to PNA. For COVID-19 infection, the choice of imaging modality should depend on the clinical team's decision. The chest CT may be negative in the early phase of the disease, and the positivity of the scan may vary with the duration of the illness. CTA chest with IV contrast can also be useful in identifying vascular

invasion in angioinvasive fungal infections and mycotic aneurysms, but it should be kept in mind that arterial phase of contrast is not optimal for evaluation of pleural enhancement for empyema or wall enhancement in lung abscesses as described under CT chest with IV contrast.

Variant 3: Adult. Acute respiratory illness in immunocompetent patients with positive physical examination or abnormal vital signs or organic brain disease or other risk factors and negative or indeterminate initial chest radiograph. Next imaging study.
E. MRI chest without and with IV contrast

MRI has the advantage of high soft tissue contrast but is not commonly used to evaluate pulmonary parenchyma and is usually not the next imaging study with a negative or indeterminate chest radiograph. In the past, image degradation by respiratory and cardiac pulsation artifacts discouraged its use for pulmonary parenchyma evaluation, but recent advances of faster sequences and respiratory gating [41] have allowed for improved quality MRI images, and it is comparable to CT for the detection of consolidations and pleural effusions. MRI is considered superior in detecting pleural adhesions and septations, especially with contrast administration [42].

Our literature search identified 1 recently published article evaluating the use of MRI in the setting of ARI in immunocompetent adult patients [43]. The study suggests a sensitivity for PNA that approaches that of CT. [43] The authors compared the sensitivity and specificity of noncontrast MRI (respiratory-triggered T2 fast spin-echo) with chest radiographs using CT as a reference 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 of 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%). Over the past 10 years, the usefulness 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 [42,44-48].

Recently, another study by Yang et al [49] showed that pulmonary MRI with ultralow echo time is valuable for assessing the representative image findings of COVID-19 with a high concordance to CT, but more research is needed because this was a single institution study, with strict selection criteria. These data suggest a potential role for MRI in detecting PNA in situations in which initial chest radiograph findings are negative or indeterminate, however, the sensitivity of CT appears to be slightly superior to that of MRI.

Variant 3: Adult. Acute respiratory illness in immunocompetent patients with positive physical examination or abnormal vital signs or organic brain disease or other risk factors and negative or indeterminate initial chest radiograph. Next imaging study.
F. MRI chest without IV contrast

MRI has the advantage of high soft tissue contrast but is not commonly used to evaluate pulmonary parenchyma. In the past, image degradation by respiratory and cardiac pulsation artifacts discouraged its use for pulmonary parenchyma evaluation, but recent advances of faster sequences and respiratory gating [41] have allowed for improved quality of MRI images, and it is comparable to CT for the detection of pleural fluid and consolidations and even considered better for improved visualization of septations and enhancement of pleura in empyema [50]. MRI is shown to be inferior in the detection of tree in bud opacities and centrilobular nodules [51].

Variant 3: Adult. Acute respiratory illness in immunocompetent patients with positive

physical examination or abnormal vital signs or organic brain disease or other risk factors and negative or indeterminate initial chest radiograph. Next imaging study.
G. US chest

There is a growing body of literature suggesting that bedside LUS can be a useful tool in the diagnosis and management of PNA but is usually not appropriate as the next imaging study with a negative or indeterminate chest radiograph [9,19-22]. Nazerian et al [21] evaluated the accuracy of US relative to CT on 285 patients who had at least 1 respiratory complaint for which the ED physician ordered a CT. CT was considered positive if at least 1 typical consolidation was detected. US identified at least 1 consolidation in 81 patients versus 87 for CT. Relative to CT, US had a sensitivity of 82.8% and a specificity of 95.5%. Although 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 they had a CT ordered rather than clinical suspicion of PNA. In the setting of COVID-19 infection, LUS can be useful as an alternate or supplemental modality for special situations like pregnant women. But specific infection prevention and control precautions are also required for transmissible infections due to closer physical proximity to the operator for a prolonged period. Studies performed by Reissig et al [22] and Bourcier et al [19] 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 indeterminate.

POCUS has been explored in health care settings where access to CT is limited or the critical condition of the patient limits the mobility to be transported to the radiology department for imaging, and it offers the assessment of lung, heart, and potential venous thromboembolism [30]. POCUS findings of B lines in COVID-19 PNA reflect the presence of an interstitial abnormality or presence of subpleural consolidation but remain nonspecific. Moreover, the positive predictive value of imaging findings is influenced by prevalence of disease. Recently, some studies have showed that chest US may be more sensitive and specific than chest radiography, as compared with chest CT, for the detection of pulmonary complications in ventilated patients with acute respiratory failure [52]. In a study by Volpicelli et al [53], 139 cases were analyzed based on clinical symptoms of COVID-19, of which RT-PCR was positive in 88 (63.3%) cases. LUS and chest radiography results were discordant in 60 (43.2%) cases. In 45 cases, a CT scan was also performed, and only 4 disagreed with LUS interpretation. However, radiographs were reviewed retrospectively, and comparison with CT was not universal; additionally, results of such studies are influenced by the prevalence of COVID-19 and other PNAs within the study population. Comparison with CT studies and RT-PCR results seems to confirm the superiority of LUS over a second retrospective reading of chest radiography. Quarato et al found a low sensitivity for LUS as compared with chest CT for the diagnosis of COVID-19 PNA in the ED. [52].

US is of limited value in patients in the setting of obesity/thick chest wall, subcutaneous gas, and in patients with limited chest wall access related to bandages, prosthetic material, and skin disorders [54]. In addition, US has difficulty identifying PNAs that are central in location due to aerated lung intervening between the transducer and the PNA [19,21,22].

Variant 3: Adult. Acute respiratory illness in immunocompetent patients with positive physical examination or abnormal vital signs or organic brain disease or other risk factors and negative or indeterminate initial chest radiograph. Next imaging study.
H. V/Q scan lung

There is no relevant literature to support the use of V/Q lung scan in the evaluation of

immunocompetent patients with a high pretest probability of PNA and a negative or indeterminate initial chest radiograph.

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

In severe cases of PNA, CT can demonstrate the overall extent of disease, which may provide important prognostic information [35]. CT can also demonstrate necrotizing PNA and abscess formation long before the findings become visible on a chest radiograph. The use of IV contrast can increase the conspicuity of empyema and other pleural complications. CT can also serve as a guide for pleural drainage or localization of an appropriate site for biopsy [55] and 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.

Variant 4: Adult. Acute respiratory illness in immunocompetent patients with pneumonia complicated by suspected parapneumonic effusion or abscess on initial chest radiograph. Next imaging study.
A. CT chest with IV contrast

CT chest with IV contrast may be useful to detect complications like lung abscess or empyema long before they are visible on a chest radiograph. Radiographs are limited in that there are no specific signs that distinguish empyema from early parapneumonic or other noninfective causes of effusions, although loculation may indicate a fibro-purulent stage of parapneumonic effusion or empyema. CT can determine the extent of the effusion and degree of loculations and also identify parenchymal lesions at the same time. The use of IV contrast can increase the conspicuity of empyema and other pleural complications. Informative CT findings of split pleura sign, pleural thickening, loculation, and extrapleural fat stranding are signs that support the diagnosis of empyema. It is important to differentiate lung abscess and empyema as treatments vary. Overlying lung disease or an unusual location of the lesion may result in uncertainty as to the diagnosis of lung abscess versus empyema on radiographs and CT can accurately localize these disorders and allow confident diagnosis, thereby affecting the management of these conditions. CT can also serve as a guide for pleural drainage or localization of an appropriate site for biopsy [55].

Variant 4: Adult. Acute respiratory illness in immunocompetent patients with pneumonia complicated by suspected parapneumonic effusion or abscess on initial chest radiograph. Next imaging study.
B. CT chest without and with IV contrast

Performing CT chest without and with IV contrast does not have added value compared to CT chest with IV contrast or CT chest without IV contrast in the evaluation of complicated PNA.

Variant 4: Adult. Acute respiratory illness in immunocompetent patients with pneumonia complicated by suspected parapneumonic effusion or abscess on initial chest radiograph. Next imaging study.
C. CT chest without IV contrast

CT chest without IV contrast can also demonstrate necrotizing PNA and abscess formation long before the findings become visible on a chest radiograph. Radiographs are limited in that there are no specific signs that distinguish empyema from early parapneumonic or other noninfective causes

of effusions, although loculation may indicate a fibro-purulent stage of parapneumonic effusion or empyema. CT can demonstrate the extent of the disease, which is an important prognostic marker and serves as an important guide for the placement of pleural drainage catheters. Administration of IV contrast allows for the detection of enhancement of the pleura in empyema and thick wall of a lung abscess with necrosis [55]. Overlying lung disease or an unusual location of the lesion may result in uncertainty as to the diagnosis of lung abscess versus empyema on radiographs, and CT can accurately localize these disorders and allow confident diagnosis, thereby affecting the management of these conditions.

Variant 4: Adult. Acute respiratory illness in immunocompetent patients with pneumonia complicated by suspected parapneumonic effusion or abscess on initial chest radiograph. Next imaging study.
D. CTA chest with IV contrast

CTA with IV contrast is useful in identifying pulmonary emboli if there is a high clinical index of suspicion. However, if a pleural effusion or lung abscess is suspected on a radiograph and needs further characterization, CTA is usually not the useful next imaging test of choice because the timing of dedicated CTA studies is suboptimal for the evaluation of pleural enhancement that typically is most conspicuous in the delayed phase and is an important CT marker for empyema in the setting of a high index of suspicion [56].

Variant 4: Adult. Acute respiratory illness in immunocompetent patients with pneumonia complicated by suspected parapneumonic effusion or abscess on initial chest radiograph. Next imaging study.
E. MRI chest without and with IV contrast

MRI has the advantage of high soft tissue contrast but is not commonly used to evaluate the pulmonary parenchyma. In the past, image degradation by respiratory and cardiac pulsation artifacts discouraged its use for pulmonary parenchyma evaluation, but recent advances of faster sequences and respiratory gating [41] have allowed its utilization in certain specific scenarios. MRI images are comparable to CT for the detection of consolidations and pleural fluid and are even considered better for the detection of pleural adhesions and septations, especially with contrast administration [50]. Altered signal intensity on T2-weighted images may be suggestive of exudative fluid in parapneumonic effusions [57]. IV contrast has the advantage of improved visualization of pleural enhancement in empyema characterized by thickened pleura, split pleura sign, and pleural septations, but the timing of the gadolinium-based contrast is important to identify their enhancement as is best visualized in delayed phase. MRI is also useful in the assessment of extrapleural fat and chest wall extension in empyemas. MRI has been shown to be inferior in the detection of tree in bud opacities and centrilobular nodules.

Variant 4: Adult. Acute respiratory illness in immunocompetent patients with pneumonia complicated by suspected parapneumonic effusion or abscess on initial chest radiograph. Next imaging study.
F. MRI chest without IV contrast

MRI has the advantage of high soft tissue contrast but is not a common modality for evaluation of pulmonary parenchyma and is usually not the next imaging study in the evaluation of PNA with suspected lung abscess or empyema. In the past, image degradation by respiratory and cardiac pulsation artifacts discouraged its use for pulmonary parenchyma evaluation, but recent advances of faster sequences and respiratory gating [41] have allowed for improved quality [41]. MRI images are comparable to CT for the detection of consolidations and pleural fluid and are even considered

better for the detection of pleural adhesions and septations, especially with contrast administration [50]. Altered signal intensity on T2 weighted images may be suggestive of exudative fluid in parapneumonic effusions [57]. MRI is also useful in the assessment of extrapleural fat and chest wall extension in empyemas. MRI has been shown to be inferior in the detection of tree in bud opacities and centrilobular nodules.

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

G. US chest

US may be appropriate for the evaluation of parapneumonic effusions because it is superior to chest radiographs for demonstrating pleural thickening and adhesions [22,54]. 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 [58].

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

H. V/Q scan lung

There is no relevant literature to support V/Q scan in the evaluation of PNA complicated by lung abscess or empyema. A V/Q scan may be ordered as the initial imaging test as an alternative to CTA chest with IV contrast for high index of suspicion for pulmonary thromboembolism if there is known allergy to IV contrast.

Variant 5: Adult. Acute asthma exacerbation in immunocompetent patients, uncomplicated. Initial imaging.

Asthma is classically characterized by bronchial hyper-responsiveness resulting in recurrent episodes of airway obstruction and reversible airflow limitation, usually in the setting of chronic airway inflammation. The incidence of PNA in patients with uncomplicated asthma exacerbation is low, but imaging can be important in detecting complications such as pneumothorax and pneumomediastinum.

Variant 5: Adult. Acute asthma exacerbation in immunocompetent patients, uncomplicated. Initial imaging.

A. CT chest with IV contrast

There is no relevant literature to support the use of CT chest with IV contrast in the initial imaging of immunocompetent patients with acute asthma exacerbation and a low pretest probability of PNA.

Variant 5: Adult. Acute asthma exacerbation in immunocompetent patients, uncomplicated. Initial imaging.

B. CT chest without and with IV contrast

There is no relevant literature to support the use of CT chest without and with IV contrast in the initial imaging of immunocompetent patients with acute asthma exacerbation and a low pretest probability of PNA.

Variant 5: Adult. Acute asthma exacerbation in immunocompetent patients, uncomplicated. Initial imaging.

C. CT chest without IV contrast

There is no relevant literature to support the use of CT chest without IV contrast in the initial imaging of immunocompetent patients with acute asthma exacerbation and a low pretest probability of PNA.

Variant 5: Adult. Acute asthma exacerbation in immunocompetent patients, uncomplicated. Initial imaging.
D. CTA chest with IV contrast

There is no relevant literature to support the use of CTA chest with IV contrast in the initial imaging of immunocompetent patients with acute asthma exacerbation and a low pretest probability of PNA.

Variant 5: Adult. Acute asthma exacerbation in immunocompetent patients, uncomplicated. Initial imaging.
E. MRI chest without and with IV contrast

There is no relevant literature to support the use of MRI chest without and with IV contrast in the initial imaging of immunocompetent patients with acute asthma exacerbation and a low pretest probability of PNA.

Variant 5: Adult. Acute asthma exacerbation in immunocompetent patients, uncomplicated. Initial imaging.
F. MRI chest without IV contrast

There is no relevant literature to support the use of MRI chest without IV contrast in the initial imaging of immunocompetent patients with acute asthma exacerbation and a low pretest probability of PNA.

Variant 5: Adult. Acute asthma exacerbation in immunocompetent patients, uncomplicated. Initial imaging.
G. Radiography chest

The incidence of PNA is exceedingly low in patients presenting with uncomplicated asthma exacerbation but may be appropriate in certain clinical scenarios and depending on provider preference. Heckerling [14] reported <2% of asthmatic patients as having pneumonic opacities. Findley and Sahn [59] observed that 99% of their patients either had a normal chest radiograph or showed only slightly prominent markings or hyperinflation. Radiographs may be useful in identifying a pneumothorax and also may show airway disease and fleeting opacities in disease like Churg-Strauss vasculitis, allergic bronchopulmonary aspergillosis, viral bronchiolitis, cystic fibrosis, and rare disorders like diffuse idiopathic pulmonary neuroendocrine cell hyperplasia, that can present clinically with asthma. Thus, radiographs may not only provide a clue to the diagnosis of such rare conditions but also predict further ordering of cross-sectional imaging for better characterization of such findings.

Variant 5: Adult. Acute asthma exacerbation in immunocompetent patients, uncomplicated. Initial imaging.
H. US chest

There is no relevant literature to support the use of US in the initial imaging of immunocompetent patients with acute asthma exacerbation and a low pretest probability of PNA.

Variant 5: Adult. Acute asthma exacerbation in immunocompetent patients, uncomplicated. Initial imaging.
I. V/Q scan lung

There is no relevant literature to support the use of V/Q lung scan in the initial imaging of immunocompetent patients with acute asthma exacerbation and a low pretest probability of PNA.

Variant 6: Adult. Acute asthma exacerbation in immunocompetent patients, complicated. Initial imaging.

Asthma can be complicated by pneumothorax, pneumomediastinum, or PNA. Pneumothorax and pneumomediastinum are the most concerning findings in patients with acute asthma exacerbation. The rate of pneumothorax has been reported as between 0.5% and 2.5% in patients of status asthmaticus who get admitted [14], and pneumothorax was found to be the direct cause of death in 27% of the cases in 1 series in patients with acute exacerbation [60]. However, the incidence of PNA in patients presenting with asthma exacerbation is low.

Variant 6: Adult. Acute asthma exacerbation in immunocompetent patients, complicated. Initial imaging.
A. CT chest with IV contrast

There is no relevant literature to support the use of CT chest with IV contrast in the initial imaging of patients with a high pretest probability of PNA or pneumothorax presenting with an acute asthma exacerbation.

Variant 6: Adult. Acute asthma exacerbation in immunocompetent patients, complicated. Initial imaging.
B. CT chest without and with IV contrast

There is no relevant literature to support the use of CT chest without and with IV contrast in the initial imaging of complicated acute asthma exacerbation and high pretest probability of PNA in immunocompetent patients.

Variant 6: Adult. Acute asthma exacerbation in immunocompetent patients, complicated. Initial imaging.
C. CT chest without IV contrast

Although the literature review did not identify any data that suggest that CT without IV contrast 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. Additional benefit of CT is the identification of findings suggesting diseases like allergic bronchopulmonary aspergillosis, eosinophilic PNA, and eosinophilic granulomatosis with polyangiitis that can manifest in the setting of asthma.

Variant 6: Adult. Acute asthma exacerbation in immunocompetent patients, complicated. Initial imaging.
D. CTA chest with IV contrast

There is no relevant literature to support the use of CTA chest with IV contrast in the initial imaging of complicated acute asthma exacerbation and high pretest probability of PNA in immunocompetent patients.

Variant 6: Adult. Acute asthma exacerbation in immunocompetent patients, complicated. Initial imaging.
E. MRI chest without and with IV contrast

There is no relevant literature to support the use of MRI chest without and with IV contrast in the initial imaging of complicated acute asthma exacerbation and high pretest probability of PNA in immunocompetent patients.

Variant 6: Adult. Acute asthma exacerbation in immunocompetent patients, complicated. Initial imaging.
F. MRI chest without IV contrast

There is no relevant literature to support the use of MRI chest without IV contrast in the initial imaging of complicated acute asthma exacerbation and high pretest probability of PNA in immunocompetent patients.

Variant 6: Adult. Acute asthma exacerbation in immunocompetent patients, complicated. Initial imaging.
G. Radiography chest

Although the use of chest radiographs in patients with an asthma exacerbation is controversial, chest radiography remains a highly effective screening tool for pneumothoraces [61]. Petheram et al [62] found clinically important radiographic findings in 9% of patients and concluded that a chest radiograph is indicated. However, the incidence of PNA in patients presenting with an asthma exacerbation is low [14,59]. Findley and Sahn [59] recommended chest radiographs only when PNA or a pneumothorax is suspected. White et al [61] found significant chest radiograph abnormalities (included increased interstitial markings [IIM], focal parenchymal opacity, pulmonary vascular congestion, enlarged cardiac silhouette, new solitary pulmonary nodule, and pneumothorax) in 34% of adults whose asthma exacerbation warranted hospital admission. A positive correlation of antibiotic use resulting in a change in management was found with radiographic focal opacities or IIM, even in afebrile patients, suggesting that chest radiographs be obtained for all adult patients admitted because of acute asthma.

Variant 6: Adult. Acute asthma exacerbation in immunocompetent patients, complicated. Initial imaging.
H. US chest

There is no relevant literature to support the use of US chest in the initial imaging of complicated acute asthma exacerbation with a high pretest probability of PNA in immunocompetent patients.

US may be a reasonable alternative to chest radiographs to identify PNA [9,19-22] and pneumothorax [54].

Variant 6: Adult. Acute asthma exacerbation in immunocompetent patients, complicated. Initial imaging.
I. V/Q scan lung

There is no relevant literature to support the use of V/Q lung scan in the initial imaging of complicated acute asthma exacerbation and high pretest probability of PNA in immunocompetent patients.

Variant 7: Adult. Acute COPD exacerbation in immunocompetent patients, uncomplicated. Initial imaging.

The ATS defines chronic obstructive pulmonary disease (COPD) flare as an acute worsening of COPD symptoms. Respiratory pathogens can play an important role in the etiology of COPD exacerbation. COPD exacerbation is characterized by airway caliber and wall changes, hyperinflation, and pulmonary vasoconstriction. Imaging can be useful in identifying COPD

phenotypes, guide management of COPD exacerbation, and show features that suggest pulmonary arterial hypertension [63,64]. Radiographs and CT may also be useful in identifying PNA causing COPD exacerbations and exclude additional associations like pulmonary edema, pneumothorax, pleural effusions, or pulmonary thromboembolism.

Variant 7: Adult. Acute COPD exacerbation in immunocompetent patients, uncomplicated. Initial imaging.
A. CT chest with IV contrast

There is no relevant literature to support the use of CT chest with IV contrast in the initial imaging of immunocompetent patients with COPD exacerbation and a low pretest probability of PNA.

Variant 7: Adult. Acute COPD exacerbation in immunocompetent patients, uncomplicated. Initial imaging.
B. CT chest without and with IV contrast

There is no relevant literature to support the use of CT chest without and with IV contrast in the initial imaging of immunocompetent patients with COPD exacerbation and a low pretest probability of PNA.

Variant 7: Adult. Acute COPD exacerbation in immunocompetent patients, uncomplicated. Initial imaging.
C. CT chest without IV contrast

There is no relevant literature to support the use of CT chest without IV contrast in the initial imaging of immunocompetent patients with COPD exacerbation and a low pretest probability of PNA.

Variant 7: Adult. Acute COPD exacerbation in immunocompetent patients, uncomplicated. Initial imaging.
D. CTA chest with IV contrast

There is no relevant literature to support the use of CTA chest with IV contrast in the initial imaging of immunocompetent patients with COPD exacerbation and a low pretest probability of PNA. If there is a high index of clinical suspicion of pulmonary embolism, a CTPA can be ordered.

Variant 7: Adult. Acute COPD exacerbation in immunocompetent patients, uncomplicated. Initial imaging.
E. MRI chest without and with IV contrast

There is no relevant literature to support the use of MRI chest without and with IV contrast in the initial imaging of immunocompetent patients with COPD exacerbation and a low pretest probability of PNA.

Variant 7: Adult. Acute COPD exacerbation in immunocompetent patients, uncomplicated. Initial imaging.
F. MRI chest without IV contrast

There is no relevant literature to support the use of MRI chest without IV contrast in the initial imaging of immunocompetent patients with COPD exacerbation and a low pretest probability of PNA.

Variant 7: Adult. Acute COPD exacerbation in immunocompetent patients, uncomplicated. Initial imaging.
G. Radiography chest

Chest radiographs seem warranted in patients with COPD 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). The "uncomplicated" exacerbation might be arising from pathology that could be detected at imaging including radiograph or CT. A few studies have found PNA manifesting as opacities on radiographs in 42.6% and 54% of their population with COPD exacerbation. Respiratory infections, most commonly viral infections but other organisms as well, may play a role in COPD exacerbations. Sherman et al [65] 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 a significant change in management in only 4.5%, which included congestive heart failure in 8 patients, PNA in 3 patients, and pneumothorax in 1 patient.

Variant 7: Adult. Acute COPD exacerbation in immunocompetent patients, uncomplicated. Initial imaging.
H. US chest

There is no relevant literature that suggests that US serves any significant role in the initial imaging of immunocompetent patients with COPD exacerbation and a low pretest probability of PNA.

Variant 7: Adult. Acute COPD exacerbation in immunocompetent patients, uncomplicated. Initial imaging.
I. V/Q scan lung

There is no relevant literature to support the use of V/Q lung scan in the initial imaging of immunocompetent patients with COPD exacerbation and a low pretest probability of PNA.

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

COPD exacerbation is characterized by airway caliber and wall changes, hyperinflation, pulmonary vasoconstriction, and imaging features that can be suggestive of pulmonary arterial hypertension. During COPD exacerbation and in the presence of comorbidities, imaging may prove valuable not only for confirming the exacerbation diagnosis but also for assessing additional pathologies such as pleural effusion, consolidation from PNA, pulmonary edema, pulmonary thromboembolism, and bronchiectasis. Imaging can be useful in identifying phenotypes and management of COPD exacerbation.

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

There is no relevant literature to support the use of CT chest with IV contrast in the initial imaging of immunocompetent patients with a high pretest probability of PNA in acute complicated COPD exacerbation.

Variant 8: Adult. Acute COPD exacerbation in immunocompetent patients with accompanying chest pain, or fever, or leukocytosis, or a history of coronary artery disease, or heart failure. Initial imaging.
B. CT chest without and with IV contrast

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 initial chest radiograph is negative or indeterminate. In

patients with significant underlying emphysema, widespread alveolar destruction can result in more subtle, interstitial manifestations on imaging ("Swiss cheese" PNA). In these cases, CT may help confirm the diagnosis.

Variant 8: Adult. Acute COPD exacerbation in immunocompetent patients with accompanying chest pain, or fever, or leukocytosis, or a history of coronary artery disease, or heart failure. Initial imaging.
C. CT chest without IV contrast

There is no relevant literature to support the use of CT chest without and with IV contrast in the initial imaging of immunocompetent patients with a high pretest probability of PNA in acute complicated COPD exacerbation.

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

There is no relevant literature to support the use of CT in the evaluation of initial imaging of immunocompetent patients with a high pretest probability of PNA in acute complicated COPD exacerbation. The prevalence of pulmonary embolism in patients with COPD hospitalized for severe exacerbation of unknown origin increases in the setting of prior thromboembolism, malignant disease, and decrease in partial pressure of carbon dioxide (PaCO2) of at least of <5 mm hg, and in such settings and with high clinical suspicion for pulmonary embolism, CTA chest with IV contrast may be appropriate as the initial imaging test.

Variant 8: Adult. Acute COPD exacerbation in immunocompetent patients with accompanying chest pain, or fever, or leukocytosis, or a history of coronary artery disease, or heart failure. Initial imaging.
E. MRI chest without and with IV contrast

There is no relevant literature to support the use of MRI chest without and with IV contrast in the evaluation of initial imaging of immunocompetent patients with a high pretest probability of PNA in acute complicated COPD exacerbation.

Variant 8: Adult. Acute COPD exacerbation in immunocompetent patients with accompanying chest pain, or fever, or leukocytosis, or a history of coronary artery disease, or heart failure. Initial imaging.
F. MRI chest without IV contrast

There is no relevant literature to support the use of MRI chest without IV contrast in the evaluation of initial imaging of immunocompetent patients with a high pretest probability of PNA in acute complicated COPD exacerbation.

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

Chest radiographs seem warranted in patients with COPD 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). In a study by Sherman et al [65], out of the 242 patients hospitalized for acute COPD exacerbation, routine chest radiographs were abnormal in 14% of patients but resulted in clinically significant abnormalities in only 4.5% of cases, which included

congestive heart failure in 8 patients, PNA in 3 patients, and pneumothorax in 1 patient. Of this group, 135 patients (56%) had asthma, and 107 (44%) had emphysema and chronic bronchitis. Additionally, a few studies have found PNA manifesting as opacities on radiographs in 42.6% and 54% of their population with COPD exacerbation. Therefore, it was 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.

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

Studies by Reissig et al [22] and Nazerian et al [21] 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 alter the sensitivity of US to diagnose complications.

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

There is no relevant literature to support the use of V/Q lung scan in the evaluation of initial imaging of immunocompetent patients with a high pretest probability of PNA in complicated acute COPD exacerbation. Despite this, the prevalence of pulmonary embolism in patients with COPD hospitalized for severe exacerbation of unknown origin increases in the setting of prior thromboembolism, malignant disease, and decrease in PaCO2 of at least of <5 mm hg, and in such settings in conjunction with high clinical suspicion for pulmonary embolism, a V/Q scan may be ordered as the initial imaging test as an alternative to CTA chest with IV contrast.

Variant 9: Adult. Acute respiratory illness in immunocompetent patients with suspected pneumonia on initial imaging. Follow-up imaging to ensure resolution.

Malignancy may manifest with a radiographic appearance similar to PNA; hence, a follow-up chest radiograph is often recommended to ensure resolution of the imaging findings and to exclude an alternative diagnosis. Although the American College of Chest Physicians [66] 2005 guidelines recommend a follow-up chest radiograph approximately 8 weeks after diagnosis, the 2007 IDSA/ATS [16] consensus guidelines for management of CAP do not recommend any follow-up imaging. Currently, no guidelines or consensus exists pertaining to the clinical value of follow-up radiographs after CAP. In the scenario of ARI in an immunocompetent patient with suspected PNA, follow-up imaging in 6 to 12 weeks may be performed to confirm resolution of imaging findings. This approach aims to minimize delays in appropriate intervention and treatment, particularly in cases in which imaging abnormalities persist, potentially indicating conditions like primary lung cancer or lymphoma. Additionally, the imaging modality (eg, radiograph or CT) used for follow-up to ensure resolution of the opacities should ideally be the same in which the suspected PNA was first detected.

Variant 9: Adult. Acute respiratory illness in immunocompetent patients with suspected pneumonia on initial imaging. Follow-up imaging to ensure resolution.
A. CT chest with IV contrast

Chest CT has a higher detection rate of nodules and better characterization of pulmonary and hilar abnormalities detected on radiographs. Although not limited to cases of suspected PNA, a study

by Harvey [67] showed that a radiologist recommendation for chest CT prompted by an index abnormal radiograph had a high yield of clinically relevant findings in 41%, nonclinically relevant corresponding abnormalities in 20.6%, and newly diagnosed, biopsy-proven malignancies in 8.1% of cases. Little et al [68] showed that 7.3% of patients, referred from general medicine clinics, specialty clinics, and the ED linked to a tertiary care academic center, underwent CT follow-up instead of radiograph follow-up, for an abnormal finding on an outpatient chest radiographic examination for suspected PNA. In 7.7% of the CT scans performed, there were malignancies corresponding to findings on the index radiographs. Increasing patient age ($P < .001$) and positive smoking history ($P = .001$) were also associated with increased likelihood of a recommendation for chest CT examination than a radiograph, likely in the light of high suspicion of malignancy. Ninety percent of the cohort underwent repeat radiograph, and one-third showed persistent abnormality, of which half had a chest CT performed for assessment of the persistent abnormality. However, this study was limited to outpatients, and only radiology reports were used for analysis. In addition, the study design did not allow comparison of outcomes between patients with and without follow-up radiographs.

Follow-up imaging with CT may serve a role in immunocompetent patients with a high pretest probability of malignancy such as those of older age, smokers or ex-smokers, or those with COPD or a history of malignancy [69]. However, the cost/benefit ratio of using chest CT for follow-up imaging of CAP is unclear given the potential risks of overdiagnosis and radiation exposure, and the follow-up imaging modality should remain the same as in which the lesion was identified initially.

Variant 9: Adult. Acute respiratory illness in immunocompetent patients with suspected pneumonia on initial imaging. Follow-up imaging to ensure resolution.
B. CT chest without and with IV contrast

There is no relevant literature to support the use of CT chest without and with IV contrast in follow-up imaging to ensure resolution of PNA.

Variant 9: Adult. Acute respiratory illness in immunocompetent patients with suspected pneumonia on initial imaging. Follow-up imaging to ensure resolution.
C. CT chest without IV contrast

Chest CT has a higher detection rate of nodules and better characterization of pulmonary abnormalities detected on radiographs. Although not limited to cases of suspected PNA, a study by Harvey [67] showed that a radiologist recommendation for chest CT prompted by an index abnormal radiograph had a high yield of clinically relevant findings in 41%, nonclinically relevant corresponding abnormalities in 20.6%, and newly diagnosed, biopsy-proven malignancies in 8.1% of cases. Little et al [68] showed that 7.3% of their cohort, referred from general medicine clinics, specialty clinics, and ED associated with a tertiary care academic center, had a CT follow-up abnormality instead of a radiograph follow-up for the assessment of an abnormal finding on an outpatient chest radiographic examination for suspected PNA and that 7.7% of the CT scans showed malignant findings that corresponded to the index finding on the radiograph. Increasing patient age ($P < .001$) and positive smoking history ($P = .001$) were also associated with increased likelihood of a recommendation for chest CT examination than a radiograph, likely in the light of high suspicion of malignancy. Ninety percent of the cohort underwent repeat radiograph, and one-third showed persistent abnormality, out of which half had a chest CT performed for assessment of the persistent abnormality. However, this study was limited to outpatients, and only radiology reports were used for analysis. In addition, the study design did not allow comparison of outcomes

between patients with and without follow-up radiographs.

Follow-up imaging with CT may serve a role in immunocompetent patients with a high pretest probability of malignancy such as those of older age, smokers, or ex-smokers, or those with COPD or a history of malignancy. However, the cost/benefit ratio of using chest CT for follow-up imaging of CAP is unclear given the potential risks of overdiagnosis and radiation exposure, and the follow-up imaging modality should remain the same as in which the lesion was identified initially.

Variant 9: Adult. Acute respiratory illness in immunocompetent patients with suspected pneumonia on initial imaging. Follow-up imaging to ensure resolution.
D. CTA chest with IV contrast

There is no relevant literature to support the use of CTA chest with IV contrast in follow-up imaging to ensure resolution of PNA.

Variant 9: Adult. Acute respiratory illness in immunocompetent patients with suspected pneumonia on initial imaging. Follow-up imaging to ensure resolution.
E. MRI chest without and with IV contrast

There is no relevant literature to support the use of MRI chest without and with IV contrast in follow-up imaging to ensure resolution of PNA.

Variant 9: Adult. Acute respiratory illness in immunocompetent patients with suspected pneumonia on initial imaging. Follow-up imaging to ensure resolution.
F. MRI chest without IV contrast

There is no relevant literature to support the use of MRI chest without IV contrast in follow-up imaging to ensure resolution of PNA.

Variant 9: Adult. Acute respiratory illness in immunocompetent patients with suspected pneumonia on initial imaging. Follow-up imaging to ensure resolution.
G. Radiography chest

Many physicians recommend follow-up chest imaging after a diagnosis of PNA at radiography or CT to exclude pulmonary malignancy or other important disease. There is a broad range (0.4%-9.2%) of reported rates of incidence of lung cancer on follow-up of patients diagnosed with CAP. Some of the older studies identified a malignancy rate of <2% but were limited by a short and unclear follow-up period (<3 months) and inclusion of a younger population, who are at very low risk for pulmonary malignancies [68,70-72]. In 1 study of 232 patients with lung cancer, 29 (12.5%) presented with an acute respiratory tract infection. A majority of these patients did not recover and were diagnosed by follow-up chest radiographs showing persistence of abnormalities [70].

In a long-term follow-up study performed in the Veterans Affairs medical system, 9.2% of CAP survivors had a new diagnosis of cancer. The mean time to diagnosis of cancer was 42 weeks 297 days, but only 27% were diagnosed within 90 days of discharge from hospital [72,73]. The population included in this study was older, at a higher risk for pulmonary malignancy, and was followed for a much longer period (up to 5 years).

The detection rate of a new lung cancer varies by the time of the follow-up radiograph, because its incidence was 1.1% at 90 days, 1.7% at 1 year, and 2.3% over 5 years [74]. The median time to diagnosis was 109 days. A few studies have examined the incidence of diagnosed pulmonary malignancy after hospitalization for PNA. In a study by Macdonald et al [69] of patients admitted

for PNA, imaging follow-up at 6 to 12 weeks found a 2% incidence of lung cancer. The study included 302 patients out of which 53% received a follow-up chest radiograph within 6 to 12 weeks after admission. Patients with a diagnosis of aspiration, hospital-acquired PNA, or with a known diagnosed lung cancer or metastatic disease were excluded. However, the study was limited by a small sample size and short follow-up period and included only patients who were admitted to hospital under general medicine with CAP.

Research conducted by Little et al [68] revealed that in 5.2% of individuals, follow-up imaging for suspected PNA led to the identification of a significant new pulmonary diagnosis. In 1.5% of the population, the index abnormality on chest radiography suspected to be PNA was found to be a newly diagnosed malignancy. In 3.7% of the population, an alternative nonmalignant disease corresponded to the index abnormality seen on the radiograph. A similar reported rate of malignancy is found in other studies [68,74,75]. In contrast to other referenced studies, the study by Little et al documented a correspondence between the index chest radiograph abnormality and lung cancer, suggesting that the opacity was either caused by the lung cancer itself or directly associated with it. This differs from other research, which primarily focuses on the epidemiological association between PNA and lung cancer.

Age >50 years has been shown to be an independent risk factor associated with increased detection of lung malignancy [68,72,74]. In the research conducted by Tang et al [74] and Mortensen et al [73], individuals who were smokers, ex-smokers, or diagnosed with COPD exhibited an independent association with the detection of lung cancer. The latter group would also qualify for inclusion in lung cancer screening studies. Consequently, follow-up imaging of radiographically suspected PNA results in a small proportion of new malignancy diagnoses and significant nonmalignant conditions, potentially prompting changes in patient management.

The current IDSA/ATS clinical practice guideline (Diagnosis and Treatment of Adults with Community-acquired Pneumonia) does not endorse imaging follow-up of PNA for patients with clinical symptoms that resolve within 7 days due to limited published evidence. However, ongoing research may identify specific patient groups that could potentially benefit from additional radiological assessment following initial therapy for PNA [72].

Variant 9: Adult. Acute respiratory illness in immunocompetent patients with suspected pneumonia on initial imaging. Follow-up imaging to ensure resolution.
H. US chest

There is no relevant literature to support the use of US chest in follow-up imaging to ensure resolution of PNA.

Variant 9: Adult. Acute respiratory illness in immunocompetent patients with suspected pneumonia on initial imaging. Follow-up imaging to ensure resolution.
I. V/Q scan lung

There is no relevant literature to support the use of V/Q scan lung in follow-up imaging to ensure resolution of PNA.

Summary of Highlights

This is a summary of the key recommendations from the variant tables. Refer to the complete narrative document for more information.

- **Variants 1 and 5**: Chest radiography may be appropriate in uncomplicated asthma exacerbations and in ARI in immunocompetent adult patients with negative physical examination, normal vital signs, and no other risk factors for poor outcome depending on the provider's clinical concerns and the patient's reliability for follow-up. Imaging is not indicated as a screening test for COVID-19 in asymptomatic individuals or for patients with clinical features of mild severity as the yield in these settings is very low and for most patients self-monitoring for clinical worsening is feasible and safe.
- **Variant 2 and 6**: Chest radiography is usually appropriate as the first-line imaging modality for complicated asthma exacerbations and in immunocompetent patients with ARI and positive physical examination, abnormal vital signs, or organic brain disease, or other risk factors for poor outcome.
- **Variant 3**: CT chest without IV contrast or CT chest with IV contrast (one or the other) is usually appropriate in adult immunocompetent patients with ARI with positive physical examination, abnormal vital signs, organic brain disease, or other risk factors and negative or indeterminate initial chest radiograph. CTA chest with IV contrast may be appropriate in certain clinical situations such as patients with suspected pneumonia and coexistent pulmonary thromboembolic disease.
- **Variant 4**: CT chest without IV contrast or CT chest with IV contrast (one or the other) is usually appropriate as the next imaging study in in immunocompetent adults with pneumonia and suspected parapneumonic effusion or abscess. US may be appropriate for the evaluation of parapneumonic effusions as it is superior to chest radiographs for demonstrating pleural thickening and adhesions and 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.
- **Variants 7 and 8**: Chest radiography is usually appropriate as the first-line imaging modality in adult immunocompetent patients, with acute uncomplicated and complicated COPD exacerbations. CTA chest with IV contrast may be appropriate as the initial imaging in complicated COPD exacerbations if there is concern for pulmonary thromboembolism as a cause of the exacerbation.
- **Variant 9**: Performing chest radiography 6 to 12 weeks after suspected pneumonia is usually appropriate to confirm resolution and exclude underlying malignancy. CT chest without IV contrast or CT chest with IV contrast (one or the other) may be appropriate if the suspected pneumonia was initially detected by CT.

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.

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Disclaimer

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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