

**American College of Radiology  
ACR Appropriateness Criteria®**  
**Pneumonia in the Immunocompetent Child**

**Variant: 1 Child. 3 months of age and older. Immunocompetent. Suspected uncomplicated community-acquired pneumonia in a well-appearing child who does not require hospitalization. Initial imaging.**

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

**Variant: 2 Child. 3 months of age and older. Immunocompetent. Community-acquired pneumonia that does not respond to initial outpatient treatment or requires hospital admission. Initial imaging.**

Procedure	Appropriateness Category	Peds Relative Radiation Level
Radiography chest	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 with IV contrast	Usually Not Appropriate	⊕⊕⊕⊕
CT chest without and with IV contrast	Usually Not Appropriate	⊕⊕⊕⊕
CT chest without IV contrast	Usually Not Appropriate	⊕⊕⊕⊕

**Variant: 3 Child. 3 months of age and older. Immunocompetent. Suspected hospital-acquired pneumonia. Initial imaging.**

Procedure	Appropriateness Category	Peds Relative Radiation Level
Radiography chest	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 with IV contrast	Usually Not Appropriate	⊕⊕⊕⊕
CT chest without and with IV contrast	Usually Not Appropriate	⊕⊕⊕⊕
CT chest without IV contrast	Usually Not Appropriate	⊕⊕⊕⊕

**Variant: 4 Child. Immunocompetent. Pneumonia complicated by suspected moderate or large parapneumonic effusion by chest radiograph. Next imaging study.**

Procedure	Appropriateness Category	Peds Relative Radiation Level
US chest	Usually Appropriate	O
Radiography chest decubitus view	May Be Appropriate	⊕

CT chest with IV contrast	May Be Appropriate	⊕⊕⊕⊕
MRI chest without and with IV contrast	Usually Not Appropriate	O
MRI chest without IV contrast	Usually Not Appropriate	O
CT chest without and with IV contrast	Usually Not Appropriate	⊕⊕⊕⊕
CT chest without IV contrast	Usually Not Appropriate	⊕⊕⊕⊕

**Variant: 5 Child. Immunocompetent. Pneumonia complicated by suspected bronchopleural fistula by chest radiograph. Next imaging study.**

Procedure	Appropriateness Category	Peds Relative Radiation Level
CT chest with IV contrast	Usually Appropriate	⊕⊕⊕⊕
CT chest without IV contrast	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 without and with IV contrast	Usually Not Appropriate	⊕⊕⊕⊕

**Variant: 6 Child. Immunocompetent. Pneumonia complicated by suspected lung abscess by chest radiograph. Next imaging study.**

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

**Variant: 7 Child. 3 months of age and older. Immunocompetent. Recurrent nonlocalized pneumonia by chest radiograph. Next imaging study.**

Procedure	Appropriateness Category	Peds Relative Radiation Level
CT chest without IV contrast	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	⊕⊕⊕⊕

**Variant: 8 Child. 3 months of age and older. Immunocompetent. Recurrent localized pneumonia by chest radiograph. Next imaging study.**

Procedure	Appropriateness Category	Peds Relative Radiation Level
CT chest with IV contrast	Usually Appropriate	⊕⊕⊕⊕
CTA chest with IV contrast	Usually Appropriate	⊕⊕⊕⊕
CT chest without IV contrast	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 without and with IV contrast	Usually Not Appropriate	⊕⊕⊕⊕
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## Panel Members

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## Summary of Literature Review

### Introduction/Background

Pneumonia is one of the most common acute infections and the single greatest infectious cause of death in children worldwide, accounting for 16% of all deaths in children under 5 years of age [1,2]. Properly recognizing, diagnosing, and treating pneumonia and its complications are of vital importance. Pneumonia can be defined clinically as the presence of fever and/or acute respiratory symptoms [3-5]. However, the clinical symptoms often lack sensitivity and specificity for the diagnosis of pneumonia [5]. Imaging plays a limited role in uncomplicated pneumonia and is primarily reserved for diagnosis of pneumonia in more severe presentations, including significant respiratory distress, hypoxemia, failed antibiotic therapy, or for suspected complications [3,6]. Resolution of radiographic findings may lag behind the clinical presentation [3,7], and imaging is not specific for the causative organism [6].

Although pneumonia can be caused by a countless number of pathogens, in the previously healthy child, there is often a specific subgroup of bacteria, viruses, fungi, or mycobacterium most commonly implicated [6]. Among these, specific etiologies can vary based on age groups. Neonatal pneumonia is covered in a separate document that relates to fever in a neonate (see the ACR Appropriateness Criteria® topic on "[Fever Without Source or Unknown Origin—Child](#)" [8]). For the infant, toddler, and preschool subgroups, viruses are the most common pathogens, with respiratory syncytial virus being the usual culprit [9]. Bacterial pneumonia is less prevalent in these age groups, and *S. pneumoniae* is by far the most common bacteria, but this is changing now because of the increasing use of a targeted vaccine for *S. pneumoniae* [3,6]. In school-aged children and young adolescents, bacterial pneumonia is more common, and *S. pneumoniae* is the most common pathogen [6]. Atypical pneumonia caused by *M. pneumoniae*, characterized by slow progression, malaise, and low-grade fever, accounts for 8% to 16% of hospitalizations [9]. Antibiotic administration for treatment of suspected bacterial pneumonia is empirical and is dictated by the known or most likely inciting organism, with consideration of patient age and clinical status [3].

Community-acquired pneumonia in children is defined as the presence of signs and symptoms of pneumonia in a previously healthy child caused by an infection acquired outside of the hospital [3].

Hospital-acquired pneumonia is most commonly defined as pneumonia that develops after 48 hours of hospitalization that was not present at the time of admission [10]. Hospital-acquired pneumonia is the second most common nosocomial infection after bloodstream infections, and

the most common of all infections acquired in intensive care units [10]. Ventilator-associated pneumonia is a subset of hospital-acquired pneumonia that occurs in mechanically ventilated children and can affect up to 12% of ventilated children [11]. A diagnosis of hospital-acquired pneumonia is based upon a new or progressive lung infiltrate along with clinical evidence that the infiltrate is of infectious origin, which includes the new onset of fever, purulent sputum, and leukocytosis [10].

The frequency of complicated pneumonia is rising [6,12]. Pleural effusion or empyema, pneumothorax, lung abscess, bronchopleural fistula, and necrotizing pneumonia are rare complications of community-acquired pneumonia with an incidence rate above 13% in children hospitalized with pneumonia [9,13,14]. It is estimated that 1% of children with community-acquired pneumonia develop pleural effusions and effusions that are seen in 13% to 28% of hospitalized children [9,13,14]. Parapneumonic effusions often resolve with antibiotic therapy, but large effusions and empyemas may require percutaneous aspiration, fibrinolysis, surgical drainage, or thoracoscopy [4,15-18]. Bronchopleural fistula develops as a complication of pneumonia if lung necrosis extends to the pleura. Bronchopleural fistula is associated with higher morbidity [17,19] and can be diagnosed clinically by seeing air bubbles in the chest tube drainage [19].

Recurrent pneumonia is defined as at least two episodes of pneumonia in 1 year, or three episodes ever, with radiographic clearing of parenchymal opacities between episodes. Recurrent pneumonia occurs in 7.7% to 9% of children with community-acquired pneumonia [20]. Recurrent pneumonia can be nonlocalized (different location) or localized (same location). In the immunocompetent child, the differential considerations for nonlocalized pneumonia includes aspiration, asthma, bronchiectasis, underlying pulmonary parenchymal damage (eg, history of bronchopulmonary dysplasia), and mucociliary deficiency [13,21]. The role of imaging is to identify any underlying anatomic lung abnormality such as bronchiectasis. In the immunocompetent child, the main differential for localized recurrent pneumonia is localized airway narrowing from intrinsic (eg, foreign body) or extrinsic cause (eg, mass, lymphadenopathy), focal bronchiectasis, underlying congenital lung abnormality (eg, congenital pulmonary airway malformation and sequestrations), underlying pulmonary parenchymal damage (eg, with history of bronchopulmonary dysplasia), and aspiration [13,21].

## **Special Imaging Considerations**

For the purposes of distinguishing between CT and CT angiography (CTA), ACR Appropriateness Criteria topics use the definition in the [ACR–NASCI–SIR–SPR Practice Parameter for the Performance and Interpretation of Body Computed Tomography Angiography \(CTA\)](#) [22]:

*"CTA uses a thin-section CT acquisition that is timed to coincide with peak arterial or venous enhancement. The resultant volumetric dataset is interpreted using primary transverse reconstructions as well as multiplanar reformations and 3-D renderings."*

All elements are essential: 1) timing, 2) reconstructions/reformats, and 3) 3-D renderings. Standard CTs with contrast also include timing issues and recons/reformats. Only in CTA; however, is 3-D rendering a required element. This corresponds to the definitions that the CMS has applied to the Current Procedural Terminology codes.

## **Discussion of Procedures by Variant**

**Variant 1: Child. 3 months of age and older. Immunocompetent. Suspected uncomplicated community-acquired pneumonia in a well-appearing child who does not require hospitalization. Initial imaging.**

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### **A. Radiography Chest**

Chest radiographs cannot reliably distinguish viral from bacterial community-acquired pneumonia and do not reliably distinguish among the various possible bacterial pathogens [4]. Chest radiographs performed in children with suspected acute lower respiratory tract infection lead to increased use of antibiotics in a clinic or emergency department setting; however, they have not been shown to affect hospitalization rates [23]. Some of the studies in this Cochran review have minor methodological flaws; however, this is the largest available systematic review and meta-analysis [23]. Therefore, the British Thoracic Society, the Pediatric Infectious Diseases Society, and the Infectious Diseases Society of America guidelines do not recommend routine radiographs for management of uncomplicated community-acquired pneumonia in nonhospitalized patients [3,4,24].

**Variant 1: Child. 3 months of age and older. Immunocompetent. Suspected uncomplicated community-acquired pneumonia in a well-appearing child who does not require hospitalization. Initial imaging.**

### **B. CT chest**

There is no relevant literature to support the use of CT as the initial imaging study in this clinical scenario.

**Variant 1: Child. 3 months of age and older. Immunocompetent. Suspected uncomplicated community-acquired pneumonia in a well-appearing child who does not require hospitalization. Initial imaging.**

### **C. US Chest**

Studies on chest ultrasound (US) are limited by the ill-defined gold standard for the diagnosis of pneumonia and varied selection of US criteria for a positive study [25-28]. However, lung US has the advantages of portability and no ionizing radiation relative to chest radiography. A meta-analysis of lung US in children when compared to a gold standard of clinical criteria and chest radiograph for the diagnosis of community-acquired pneumonia showed a sensitivity of 96% (94%–97%) and a specificity of 93% (90%–96%) [25]. Another meta-analysis showed a sensitivity of 93% (88%–96%) and a specificity of 96% (92%–98%) [27]. Other studies demonstrate a lower sensitivity of 40% compared with chest radiographs [28]. No change in outcome was reported compared with the control group evaluated by both chest radiographs and US [29].

**Variant 1: Child. 3 months of age and older. Immunocompetent. Suspected uncomplicated community-acquired pneumonia in a well-appearing child who does not require hospitalization. Initial imaging.**

### **D. MRI chest**

There is no relevant literature to support the use of MRI as the initial imaging study in this clinical scenario.

**Variant 2: Child. 3 months of age and older. Immunocompetent. Community-acquired**

**pneumonia that does not respond to initial outpatient treatment or requires hospital admission. Initial imaging.**

**Variant 2: Child. 3 months of age and older. Immunocompetent. Community-acquired pneumonia that does not respond to initial outpatient treatment or requires hospital admission. Initial imaging.**

#### **A. Radiography Chest**

Radiographs can be used to document the presence, size, and character of parenchymal infiltrates as well as to identify complications of pneumonia that may lead to interventions beyond antimicrobial agents and supportive medical therapy [3,24]. Frontal and lateral views of the chest are appropriate when evaluating for pneumonia in children with significant respiratory distress, hypoxemia, and failed antibiotic therapy, as suggested by the Pediatric Infectious Diseases Society and the Infectious Diseases Society of America [3,24,30]. Chest radiographs should be performed in select patients with prolonged fever and cough even in the absence of tachypnea or respiratory distress [3].

**Variant 2: Child. 3 months of age and older. Immunocompetent. Community-acquired pneumonia that does not respond to initial outpatient treatment or requires hospital admission. Initial imaging.**

#### **B. CT chest**

There is no relevant literature to support the use of CT as the initial imaging study in this clinical scenario.

**Variant 2: Child. 3 months of age and older. Immunocompetent. Community-acquired pneumonia that does not respond to initial outpatient treatment or requires hospital admission. Initial imaging.**

#### **C. US Chest**

Studies on chest US are limited by the ill-defined gold standard for the diagnosis of pneumonia and varied selection of US criteria for a positive study [25-28]. However, lung US has the advantages of portability and no ionizing radiation relative to chest radiography. A meta-analysis of lung US in children when compared to a gold standard of clinical criteria and chest radiograph for the diagnosis of community-acquired pneumonia showed a sensitivity of 96% (94%–97%) and a specificity of 93% (90%–96%) [25]. Another meta-analysis showed a sensitivity of 93% (88%–96%) and a specificity of 96% (92%–98%) [27]. Other studies demonstrate a lower sensitivity of 40% compared with chest radiographs [28]. No change in outcome was reported compared with the control group evaluated by both chest radiographs and US [29].

**Variant 2: Child. 3 months of age and older. Immunocompetent. Community-acquired pneumonia that does not respond to initial outpatient treatment or requires hospital admission. Initial imaging.**

#### **D. MRI chest**

There is no relevant literature to support the use of MRI as the initial imaging study in this clinical scenario.

**Variant 3: Child. 3 months of age and older. Immunocompetent. Suspected hospital-acquired pneumonia. Initial imaging.**

**Variant 3: Child. 3 months of age and older. Immunocompetent. Suspected hospital-acquired pneumonia. Initial imaging.**

## **A. Radiography Chest**

Findings of new or progressive lung opacity support the diagnosis of hospital-acquired pneumonia in the appropriate clinical circumstances [10]. However, a new lung opacity in an inpatient with fever, leukocytosis, or leukopenia and purulent secretions is neither highly sensitive nor specific for hospital-acquired pneumonia [10,11].

### **Variant 3: Child. 3 months of age and older. Immunocompetent. Suspected hospital-acquired pneumonia. Initial imaging.**

#### **B. CT chest**

There is no relevant literature to support the use of CT as the initial imaging study in this clinical scenario.

### **Variant 3: Child. 3 months of age and older. Immunocompetent. Suspected hospital-acquired pneumonia. Initial imaging.**

#### **C. US Chest**

There is no relevant literature to support the use of US as the initial imaging study in this clinical scenario.

### **Variant 3: Child. 3 months of age and older. Immunocompetent. Suspected hospital-acquired pneumonia. Initial imaging.**

#### **D. MRI chest**

There is no relevant literature to support the use of MRI as the initial imaging study in this clinical scenario.

### **Variant 4: Child. Immunocompetent. Pneumonia complicated by suspected moderate or large parapneumonic effusion by chest radiograph. Next imaging study.**

### **Variant 4: Child. Immunocompetent. Pneumonia complicated by suspected moderate or large parapneumonic effusion by chest radiograph. Next imaging study.**

#### **A. Radiography Chest Decubitus View**

Decubitus radiographs may be helpful to distinguish free-flowing pleural effusions from loculated collections [31]. However, radiographs can neither identify the type of fluid present nor be used to visualize the internal characteristics of the fluid [32]. In a study of adult patients, radiographs had a sensitivity of 39% and specificity of 85% compared with CT for presence of an effusion [33].

### **Variant 4: Child. Immunocompetent. Pneumonia complicated by suspected moderate or large parapneumonic effusion by chest radiograph. Next imaging study.**

#### **B. CT chest**

There is limited evidence that a noncontrast chest CT is useful in this clinical scenario. Even with intravenous (IV) contrast, it may be difficult to distinguish consolidated lung from visceral pleural enhancement [34]. Contrast-enhanced CT can also be used to quantify the amount of pleural fluid and can also demonstrate pleural thickening and enhancement that is suggestive of empyema. CT has limited ability to characterize the internal characteristics of parapneumonic effusions (eg, fibrin strands, septations, and complex fluid) [31,34-37].

### **Variant 4: Child. Immunocompetent. Pneumonia complicated by suspected moderate or large parapneumonic effusion by chest radiograph. Next imaging study.**

#### **C. US Chest**

US is the gold standard imaging for quantifying the size and identifying the internal characteristics

of a pleural effusion. In a study of adult patients, US had a sensitivity of 92% and specificity of 93% compared with CT for presence of an effusion [33]. US can also be used to guide drainage of pleural fluid and complicated parapneumonic effusions [16,26,34,38]. US is superior to chest CT for effusion characterization (eg, fibrin strands, septations, and complex fluid) [31,34-36,39].

**Variant 4: Child. Immunocompetent. Pneumonia complicated by suspected moderate or large parapneumonic effusion by chest radiograph. Next imaging study.**

**D. MRI chest**

There is limited evidence that MRI is the best imaging modality to evaluate a pleural effusion. MRI has a similar sensitivity and specificity to CT for detection of pleural effusions [40-43]. Empyemas are typically well characterized on MRI because of the modality's excellent tissue contrast resolution. Findings of empyema on MRI include thickening and hyperenhancement of the pleura, septations within the pleural space, restricted diffusion on diffusion-weighted sequences, and heterogeneous signal within pleural fluid that is due to debris [44]. However, clinically unstable patients can be difficult to manage in the MRI environment. Additionally, certain pediatric-aged patients typically require sedation, and sedation can result in atelectasis that can make pleural effusion characterization more challenging.

**Variant 5: Child. Immunocompetent. Pneumonia complicated by suspected bronchopleural fistula by chest radiograph. Next imaging study.**

**Variant 5: Child. Immunocompetent. Pneumonia complicated by suspected bronchopleural fistula by chest radiograph. Next imaging study.**

**A. CT chest**

CT chest without IV contrast can detect bronchopleural fistulae [45]. A direct sign on CT of a bronchopleural fistula is a fistulous tract between the bronchus or lung and pleural space. An indirect sign of a bronchopleural fistula is the presence of air bubbles beneath the bronchial stump or suspected fistula [45].

CT chest with IV contrast can show the same findings as CT chest without IV contrast [45]. Additionally, CT chest with IV contrast can show important findings, such as necrotizing pneumonia, pulmonary abscess, and empyema that may be the underlying cause of the bronchopleural fistula [13,19,35,46-48]. There is no evidence directly comparing CT chest without IV contrast and CT chest with IV contrast in diagnosis of bronchopleural fistula.

**Variant 5: Child. Immunocompetent. Pneumonia complicated by suspected bronchopleural fistula by chest radiograph. Next imaging study.**

**B. US Chest**

There is no relevant literature to support the use of US as the initial imaging study in this clinical scenario.

**Variant 5: Child. Immunocompetent. Pneumonia complicated by suspected bronchopleural fistula by chest radiograph. Next imaging study.**

**C. MRI Chest**

There is no relevant literature supporting the use of MRI as the initial imaging study in this clinical scenario.

**Variant 6: Child. Immunocompetent. Pneumonia complicated by suspected lung abscess by chest radiograph. Next imaging study.**

**Variant 6: Child. Immunocompetent. Pneumonia complicated by suspected lung abscess by chest radiograph. Next imaging study.**

**A. CT chest**

In the context of diagnosing necrotizing pneumonia or pulmonary abscess, contrast-enhanced CT is considered the gold standard for imaging [13,19,35,46,47]. CT chest with IV contrast can also differentiate between parenchymal and pleural processes [31]. There is no literature supporting the use of noncontrast CT in the evaluation of pulmonary abscess.

**Variant 6: Child. Immunocompetent. Pneumonia complicated by suspected lung abscess by chest radiograph. Next imaging study.**

**B. US Chest**

There is no literature that investigates the diagnostic accuracy of US in the setting of lung abscess. However, there is some literature that evaluates the effectiveness of US for differentiating between lung abscess and empyema, which is the main imaging mimic. This imaging differentiation is important because treatment for these conditions is often different, with abscess often treated with antibiotics and empyema often requiring drainage and antibiotics. In a reported series of 50 and 64 patients with lung abscesses, US was 94% to 96% sensitive and 96% to 100% specific for differentiating between lung abscess and empyema [49-51].

**Variant 6: Child. Immunocompetent. Pneumonia complicated by suspected lung abscess by chest radiograph. Next imaging study.**

**C. MRI Chest**

There is limited evidence that MRI has similar sensitivity for abscess compared with CT [40-42]. There are some practical considerations for MRI as an initial imaging modality because clinically unstable patients can be difficult to manage in the MRI environment. If MRI is performed, IV contrast is recommended for the evaluation of lung abscess [41]. Additionally, certain pediatric-aged patients typically require sedation, and sedation can result in atelectasis, which can make pleural effusion characterization more challenging.

**Variant 7: Child. 3 months of age and older. Immunocompetent. Recurrent nonlocalized pneumonia by chest radiograph. Next imaging study.**

**Variant 7: Child. 3 months of age and older. Immunocompetent. Recurrent nonlocalized pneumonia by chest radiograph. Next imaging study.**

**A. CT chest**

A noncontrast chest CT can be used to evaluate for an underlying pulmonary disease, such as postinfectious bronchiectasis, bronchopulmonary dysplasia, and findings such as bullae or bronchiectasis that may indicate a mucociliary deficiency [52]. There is no relevant literature regarding the use of contrast-enhanced CT in this clinical scenario.

**Variant 7: Child. 3 months of age and older. Immunocompetent. Recurrent nonlocalized pneumonia by chest radiograph. Next imaging study.**

**B. US Chest**

There is no relevant literature regarding the use of US as the initial imaging study in this clinical scenario.

**Variant 7: Child. 3 months of age and older. Immunocompetent. Recurrent nonlocalized pneumonia by chest radiograph. Next imaging study.**

**C. MRI Chest**

There is little evidence for MRI as a screening modality for causes of recurrent localized pneumonia, but it can be used to grade known or suspected disease. In one prospective study with 50 patients with noncystic fibrosis lung disease, MRI was equivalent to CT for grading central bronchiectasis and pulmonary consolidation but performed worse than CT for peripheral lung findings and for diagnosing emphysema and bullae [53]. There is no relevant literature regarding the use of contrast-enhanced MRI in this clinical scenario.

**Variant 8: Child. 3 months of age and older. Immunocompetent. Recurrent localized pneumonia by chest radiograph. Next imaging study.**

**Variant 8: Child. 3 months of age and older. Immunocompetent. Recurrent localized pneumonia by chest radiograph. Next imaging study.**

**A. CT chest**

CT chest without IV contrast can be used to diagnose anatomical abnormalities in the immunocompetent patient that could predispose children to recurrent localized infections, such as congenital lobar overinflation [54] or foreign bodies that could cause recurrent postobstructive pneumonia [13]. CT chest without IV contrast can also be used to evaluate underlying pulmonary disease like bronchopulmonary dysplasia [52].

Similar to CT chest without IV contrast, CT chest with IV contrast can be used to diagnose anatomical abnormalities in the immunocompetent patient that could predispose children to recurrent localized infections like congenital lobar overinflation [54], foreign bodies that could cause recurrent postobstructive pneumonia [13], and underlying pulmonary disease like bronchopulmonary dysplasia [52]. CT chest with IV contrast provides benefit over CT chest without IV contrast for diagnosing conditions such as bronchial tumors, congenital pulmonary airway malformation [54-58], pulmonary sequestration [21,54,55,59-63], and bronchopulmonary foregut malformations [54,55].

**Variant 8: Child. 3 months of age and older. Immunocompetent. Recurrent localized pneumonia by chest radiograph. Next imaging study.**

**B. CTA chest**

CTA chest with IV contrast is especially helpful for presurgical planning, identifying feeding and draining vessels in patients with suspected pulmonary sequestration, and assessing for a vascular ring that may lead to tracheal narrowing [59,63]. In most cases, CTA of the chest with IV contrast is preferred over CT chest with IV contrast.

**Variant 8: Child. 3 months of age and older. Immunocompetent. Recurrent localized pneumonia by chest radiograph. Next imaging study.**

**C. US Chest**

There is no relevant literature regarding the use of US as the initial imaging study in this clinical scenario.

**Variant 8: Child. 3 months of age and older. Immunocompetent. Recurrent localized pneumonia by chest radiograph. Next imaging study.**

**D. MRI Chest**

There is little evidence for MRI as a screening modality for causes of recurrent localized pneumonia, but it can be used to grade known or suspected disease. In one small prospective study, MRI was equivalent to CT for grading central bronchiectasis and pulmonary consolidations but performed worse than CT for peripheral lung findings and for diagnosing emphysema and

bullae [53].

## Summary of Highlights

- **Variant 1:** Imaging is usually not appropriate for immunocompetent children 3 months of age and older with suspected uncomplicated community-acquired pneumonia in a well-appearing child who does not require hospitalization.
- **Variant 2:** A radiograph of the chest is usually appropriate for the initial imaging of immunocompetent children 3 months of age and older with community-acquired pneumonia that does not respond to initial outpatient treatment or requires hospital admission.
- **Variant 3:** A radiograph of the chest is usually appropriate for the initial imaging of immunocompetent children 3 months of age and older with suspected hospital-acquired pneumonia.
- **Variant 4:** US chest is usually appropriate as the next imaging study for immunocompetent children with pneumonia complicated by suspected moderate or large parapneumonic effusion seen on chest radiograph.
- **Variant 5:** CT chest with IV contrast is usually appropriate as the next imaging study for immunocompetent children with pneumonia complicated by suspected bronchopleural fistula seen on chest radiograph. The panel did not agree on recommending CT chest without IV contrast as the next imaging study for immunocompetent children with pneumonia complicated by suspected bronchopleural fistula seen on chest radiograph. There is insufficient medical literature to conclude whether or not these patients would benefit from CT chest without IV contrast for this clinical scenario. CT chest without IV contrast in this patient population is controversial but may be appropriate.
- **Variant 6:** CT chest with IV contrast is usually appropriate as the next imaging study for immunocompetent children with pneumonia complicated by suspected lung abscess seen on chest radiograph.
- **Variant 7:** CT chest without IV contrast is usually appropriate as the next imaging study for immunocompetent children 3 months of age and older with recurrent nonlocalized pneumonia seen on chest radiograph.
- **Variant 8:** CTA chest with IV contrast or CT chest with IV contrast is usually appropriate as the next imaging study for immunocompetent children 3 months of age and older with recurrent localized pneumonia seen on chest radiograph. These procedures are equivalent alternatives (ie, only one procedure will be ordered to provide the clinical information to effectively manage the patient's care). The panel did not agree on recommending CT chest without IV contrast as the next imaging study for immunocompetent children 3 months of age and older with recurrent localized pneumonia seen on chest radiograph. There is insufficient medical literature to conclude whether or not these patients would benefit from CT chest without IV contrast for this clinical scenario. CT chest without IV contrast in this patient population is controversial but may be appropriate.

## Supporting Documents

The evidence table, literature search, and appendix for this topic are available at <https://acsearch.acr.org/list>. The appendix includes the strength of evidence assessment and the final rating round tabulations for each recommendation.

For additional information on the Appropriateness Criteria methodology and other supporting documents, please go to the ACR website at <https://www.acr.org/Clinical-Resources/Clinical-Tools-and-Reference/Appropriateness-Criteria>.

## Appropriateness Category Names and Definitions

Appropriateness Category Name	Appropriateness Rating	Appropriateness Category Definition
Usually Appropriate	7, 8, or 9	The imaging procedure or treatment is indicated in the specified clinical scenarios at a favorable risk-benefit ratio for patients.
May Be Appropriate	4, 5, or 6	The imaging procedure or treatment may be indicated in the specified clinical scenarios as an alternative to imaging procedures or treatments with a more favorable risk-benefit ratio, or the risk-benefit ratio for patients is equivocal.
May Be Appropriate (Disagreement)	5	The individual ratings are too dispersed from the panel median. The different label provides transparency regarding the panel's recommendation. "May be appropriate" is the rating category and a rating of 5 is assigned.
Usually Not Appropriate	1, 2, or 3	The imaging procedure or treatment is unlikely to be indicated in the specified clinical scenarios, or the risk-benefit ratio for patients is likely to be unfavorable.

## Relative Radiation Level Information

Potential adverse health effects associated with radiation exposure are an important factor to consider when selecting the appropriate imaging procedure. Because there is a wide range of radiation exposures associated with different diagnostic procedures, a relative radiation level (RRL) indication has been included for each imaging examination. The RRLs are based on effective dose, which is a radiation dose quantity that is used to estimate population total radiation risk associated with an imaging procedure. Patients in the pediatric age group are at inherently higher risk from exposure, because of both organ sensitivity and longer life expectancy (relevant to the long latency that appears to accompany radiation exposure). For these reasons, the RRL dose estimate ranges for pediatric examinations are lower as compared with those specified for adults (see Table below). Additional information regarding radiation dose assessment for imaging examinations can be found in the ACR Appropriateness Criteria® [Radiation Dose Assessment Introduction](#) document.

## Relative Radiation Level Designations

Relative Radiation Level*	Adult Effective Dose Estimate Range	Pediatric Effective Dose Estimate Range
0	0 mSv	0 mSv
	<0.1 mSv	<0.03 mSv
	0.1-1 mSv	0.03-0.3 mSv
	1-10 mSv	0.3-3 mSv



10-30 mSv

3-10 mSv

30-100 mSv

10-30 mSv

\*RRL assignments for some of the examinations cannot be made, because the actual patient doses in these procedures vary as a function of a number of factors (e.g., region of the body exposed to ionizing radiation, the imaging guidance that is used). The RRLs for these examinations are designated as "Varies."

## References

1. World Health Organization. Pneumonia. Available at: <http://www.who.int/news-room/fact-sheets/detail/pneumonia>.
2. Wardlaw T, Salama P, Johansson EW, Mason E. Pneumonia: the leading killer of children. *Lancet*. 368(9541):1048-50, 2006 Sep 23.
3. Bradley JS, Byington CL, Shah SS, et al. The management of community-acquired pneumonia in infants and children older than 3 months of age: clinical practice guidelines by the Pediatric Infectious Diseases Society and the Infectious Diseases Society of America. *Clin Infect Dis*. 53(7):e25-76, 2011 Oct.
4. Harris M, Clark J, Coote N, et al. British Thoracic Society guidelines for the management of community acquired pneumonia in children: update 2011. *Thorax*. 66 Suppl 2:ii1-23, 2011 Oct.
5. McIntosh K.. Community-acquired pneumonia in children. [Review] [83 refs]. *N Engl J Med*. 346(6):429-37, 2002 Feb 07.
6. le Roux DM, Zar HJ. Community-acquired pneumonia in children - a changing spectrum of disease. [Review][Erratum appears in *Pediatr Radiol*. 2017 Dec;47(13):1855; PMID: 29110044]. *Pediatr Radiol*. 47(11):1392-1398, 2017 Oct.
7. Bruns AH, Oosterheert JJ, El Moussaoui R, Opmeer BC, Hoepelman AI, Prins JM. Pneumonia recovery: discrepancies in perspectives of the radiologist, physician and patient. *Journal of General Internal Medicine*. 25(3):203-6, 2010 Mar.
8. American College of Radiology. ACR Appropriateness Criteria®: Fever Without Source or Unknown Origin—Child. Available at: <https://acsearch.acr.org/docs/69438/Narrative/>.
9. Jain S, Williams DJ, Arnold SR, et al. Community-acquired pneumonia requiring hospitalization among U.S. children. *N Engl J Med*. 372(9):835-45, 2015 Feb 26.
10. Cakir Edis E, Hatipoglu ON, Yilmam I, Eker A, Tansel O, Sut N. Hospital-acquired pneumonia developed in non-intensive care units. *Respiration*. 78(4):416-22, 2009.
11. Chang I, Schibler A. Ventilator Associated Pneumonia in Children. [Review]. *Paediatr Respir Rev*. 20:10-16, 2016 Sep.
12. Darby JB, Singh A, Quinonez R. Management of Complicated Pneumonia in Childhood: A Review of Recent Literature. *Rev Recent Clin Trials*. 12(4):253-259, 2017.
13. Andronikou S, Goussard P, Sorantin E. Computed tomography in children with community-acquired pneumonia. [Review]. *Pediatric Radiology*. 47(11):1431-1440, 2017 Oct. *Pediatr Radiol*. 47(11):1431-1440, 2017 Oct.
14. Byington CL, Spencer LY, Johnson TA, et al. An epidemiological investigation of a sustained high rate of pediatric parapneumonic empyema: risk factors and microbiological associations. *Clin Infect Dis*. 34(4):434-40, 2002 Feb 15.

15. Dorman RM, Vali K, Rothstein DH. Trends in treatment of infectious parapneumonic effusions in U.S. children's hospitals, 2004-2014. *J Pediatr Surg.* 51(6):885-90, 2016 Jun.
16. James CA, Braswell LE, Pezeshkmehr AH, Roberson PK, Parks JA, Moore MB. Stratifying fibrinolytic dosing in pediatric parapneumonic effusion based on ultrasound grade correlation. *Pediatr Radiol.* 47(1):89-95, 2017 Jan.
17. Lai JY, Yang W, Ming YC. Surgical Management of Complicated Necrotizing Pneumonia in Children. *Pediatr neonatol.* 58(4):321-327, 2017 Aug.
18. Redden MD, Chin TY, van Driel ML. Surgical versus non-surgical management for pleural empyema. [Review]. *Cochrane Database Syst Rev.* 3:CD010651, 2017 Mar 17.
19. Hodina M, Hanquinet S, Cotting J, Schnyder P, Gudinchet F. Imaging of cavitary necrosis in complicated childhood pneumonia. *Eur Radiol.* 12(2):391-6, 2002 Feb.
20. Montella S, Corcione A, Santamaria F. Recurrent Pneumonia in Children: A Reasoned Diagnostic Approach and a Single Centre Experience. [Review]. *Int. j. mol. sci..* 18(2), 2017 Jan 29.
21. Brand PL, Hoving MF, de Groot EP. Evaluating the child with recurrent lower respiratory tract infections. [Review]. *Paediatr Respir Rev.* 13(3):135-8, 2012 Sep.
22. American College of Radiology. ACR-NASCI-SIR-SPR Practice Parameter for the Performance and Interpretation of Body Computed Tomography Angiography (CTA). Available at: <https://gravitas.acr.org/PPTS/GetDocumentView?docId=164+&releaseId=2>.
23. Cao AM, Choy JP, Mohanakrishnan LN, Bain RF, van Driel ML. Chest radiographs for acute lower respiratory tract infections. [Review]. *Cochrane Database Syst Rev.* (12)CD009119, 2013 Dec 26.
24. Andronikou S, Lambert E, Halton J, et al. Guidelines for the use of chest radiographs in community-acquired pneumonia in children and adolescents. [Review]. *Pediatr Radiol.* 47(11):1405-1411, 2017 Oct.
25. Pereda MA, Chavez MA, Hooper-Miele CC, et al. Lung ultrasound for the diagnosis of pneumonia in children: a meta-analysis. [Review]. *Pediatrics.* 135(4):714-22, 2015 Apr.
26. Stadler JAM, Andronikou S, Zar HJ. Lung ultrasound for the diagnosis of community-acquired pneumonia in children. [Review]. *Pediatr Radiol.* 47(11):1412-1419, 2017 Oct.
27. Xin H, Li J, Hu HY. Is Lung Ultrasound Useful for Diagnosing Pneumonia in Children?: A Meta-Analysis and Systematic Review. *Ultrasound Quarterly.* 34(1):3-10, 2018 Mar.
28. Zhan C, Grundtvig N, Klug BH. Performance of Bedside Lung Ultrasound by a Pediatric Resident: A Useful Diagnostic Tool in Children With Suspected Pneumonia. *Pediatric Emergency Care.* 2016 Oct 04.
29. Jones BP, Tay ET, Elikashvili I, et al. Feasibility and Safety of Substituting Lung Ultrasonography for Chest Radiography When Diagnosing Pneumonia in Children: A Randomized Controlled Trial. *Chest.* 150(1):131-8, 2016 Jul.
30. Soudack M, Plotkin S, Ben-Shlush A, et al. The Added Value of the Lateral Chest Radiograph for Diagnosing Community Acquired Pneumonia in the Pediatric Emergency Department. *Isr Med Assoc J* 2018;20:5-8.
31. Islam S, Calkins CM, Goldin AB, et al. The diagnosis and management of empyema in

children: a comprehensive review from the APSA Outcomes and Clinical Trials Committee. [Review]. *J Pediatr Surg.* 47(11):2101-10, 2012 Nov.

**32.** King S, Thomson A. Radiological perspectives in empyema. [Review] [35 refs]. *Br Med Bull.* 61:203-14, 2002.

**33.** Lichtenstein D, Goldstein I, Mourgeon E, Cluzel P, Grenier P, Rouby JJ. Comparative diagnostic performances of auscultation, chest radiography, and lung ultrasonography in acute respiratory distress syndrome. *Anesthesiology.* 100(1):9-15, 2004 Jan.

**34.** Calder A, Owens CM. Imaging of parapneumonic pleural effusions and empyema in children. [Review] [28 refs]. *Pediatr Radiol.* 39(6):527-37, 2009 Jun.

**35.** Donnelly LF, Klosterman LA. The yield of CT of children who have complicated pneumonia and noncontributory chest radiography. *AJR Am J Roentgenol.* 170(6):1627-31, 1998 Jun.

**36.** Pinotti KF, Ribeiro SM, Cataneo AJ. Thorax ultrasound in the management of pediatric pneumonias complicated with empyema. *Pediatr Surg Int.* 22(10):775-8, 2006 Oct.

**37.** Donnelly LF, Klosterman LA. CT appearance of parapneumonic effusions in children: findings are not specific for empyema. *AJR Am J Roentgenol.* 169(1):179-82, 1997 Jul.

**38.** Chen IC, Lin MY, Liu YC, et al. The role of transthoracic ultrasonography in predicting the outcome of community-acquired pneumonia in hospitalized children. *PLoS ONE.* 12(3):e0173343, 2017.

**39.** Kurian J, Levin TL, Han BK, Taragin BH, Weinstein S. Comparison of ultrasound and CT in the evaluation of pneumonia complicated by parapneumonic effusion in children. *AJR Am J Roentgenol.* 193(6):1648-54, 2009 Dec.

**40.** Gorkem SB, Coskun A, Yikilmaz A, Zurakowski D, Mulkern RV, Lee EY. Evaluation of pediatric thoracic disorders: comparison of unenhanced fast-imaging-sequence 1.5-T MRI and contrast-enhanced MDCT. *AJR Am J Roentgenol.* 200(6):1352-7, 2013 Jun.

**41.** Liszewski MC, Gorkem S, Sodhi KS, Lee EY. Lung magnetic resonance imaging for pneumonia in children. [Review]. *Pediatr Radiol.* 47(11):1420-1430, 2017 Oct.

**42.** Sodhi KS, Khandelwal N, Saxena AK, et al. Rapid lung MRI in children with pulmonary infections: Time to change our diagnostic algorithms. *Journal of Magnetic Resonance Imaging.* 43(5):1196-206, 2016 May.

**43.** Yikilmaz A, Koc A, Coskun A, Ozturk MK, Mulkern RV, Lee EY. Evaluation of pneumonia in children: comparison of MRI with fast imaging sequences at 1.5T with chest radiographs. *Acta Radiol.* 2011;52(8):914-919.

**44.** Peltola V, Ruuskanen O, Svedstrom E. Magnetic resonance imaging of lung infections in children. *Pediatr Radiol.* 2008;38(11):1225-1231.

**45.** Seo H, Kim TJ, Jin KN, Lee KW. Multi-detector row computed tomographic evaluation of bronchopleural fistula: correlation with clinical, bronchoscopic, and surgical findings. *J Comput Assist Tomogr.* 34(1):13-8, 2010 Jan.

**46.** Ramgopal S, Ivan Y, Medsinge A, Saladino RA. Pediatric Necrotizing Pneumonia: A Case Report and Review of the Literature. [Review]. *Pediatr Emerg Care.* 33(2):112-115, 2017 Feb.

**47.** Lai SH, Wong KS, Liao SL. Value of Lung Ultrasonography in the Diagnosis and Outcome Prediction of Pediatric Community-Acquired Pneumonia with Necrotizing Change. *PLoS*

ONE. 10(6):e0130082, 2015.

48. Nair A, Godoy MC, Holden EL, et al. Multidetector CT and postprocessing in planning and assisting in minimally invasive bronchoscopic airway interventions. [Review]. *Radiographics*. 32(5):E201-32, 2012 Sep-Oct.
49. Chen HJ, Yu YH, Tu CY, et al. Ultrasound in peripheral pulmonary air-fluid lesions. Color Doppler imaging as an aid in differentiating empyema and abscess. *Chest*. 135(6):1426-1432, 2009 Jun.
50. Wu HD, Yang PC, Lee LN. Differentiation of lung abscess and empyema by ultrasonography. *J Formos Med Assoc*. 90(8):749-54, 1991 Aug.
51. Yang PC, Luh KT, Lee YC, et al. Lung abscesses: US examination and US-guided transthoracic aspiration. *Radiology*. 180(1):171-5, 1991 Jul.
52. Tonson la Tour A, Spadola L, Sayegh Y, et al. Chest CT in bronchopulmonary dysplasia: clinical and radiological correlations. *Pediatric Pulmonology*. 48(7):693-8, 2013 Jul.
53. Montella S, Maglione M, Bruzzese D, et al. Magnetic resonance imaging is an accurate and reliable method to evaluate non-cystic fibrosis paediatric lung disease. *Respirology*. 17(1):87-91, 2012 Jan.
54. Lee EY, Tracy DA, Mahmood SA, Weldon CB, Zurakowski D, Boiselle PM. Preoperative MDCT evaluation of congenital lung anomalies in children: comparison of axial, multiplanar, and 3D images. *AJR. American Journal of Roentgenology*. 196(5):1040-6, 2011 May.
55. Saeed A, Kazmierski M, Khan A, McShane D, Gomez A, Aslam A. Congenital lung lesions: preoperative three-dimensional reconstructed CT scan as the definitive investigation and surgical management. *European Journal of Pediatric Surgery*. 23(1):53-6, 2013 Feb.
56. Griffin N, Devaraj A, Goldstraw P, Bush A, Nicholson AG, Padley S. CT and histopathological correlation of congenital cystic pulmonary lesions: a common pathogenesis?. *Clinical Radiology*. 63(9):995-1005, 2008 Sep.
57. Shimohira M, Hara M, Kitase M, et al. Congenital pulmonary airway malformation: CT-pathologic correlation. *Journal of Thoracic Imaging*. 22(2):149-53, 2007 May.
58. Thakkar HS, Durell J, Chakraborty S, et al. Antenatally Detected Congenital Pulmonary Airway Malformations: The Oxford Experience. *European Journal of Pediatric Surgery*. 27(4):324-329, 2017 Aug.
59. Buyukoglan H, Mavili E, Tutar N, et al. Evaluation of diagnostic accuracy of computed tomography to assess the angioarchitecture of pulmonary sequestration. *Tuberkuloz ve Toraks*. 59(3):242-7, 2011.
60. Long Q, Zha Y, Yang Z. Evaluation of pulmonary sequestration with multidetector computed tomography angiography in a select cohort of patients: A retrospective study. *Clinics (Sao Paulo, Brazil)*. 71(7):392-8, 2016 Jul.
61. Ren JZ, Zhang K, Huang GH, et al. Assessment of 64-row computed tomographic angiography for diagnosis and pretreatment planning in pulmonary sequestration. *Radiologia Medica*. 119(1):27-32, 2014 Jan.
62. Yoon HM, Kim EA, Chung SH, et al. Extralobar pulmonary sequestration in neonates: The natural course and predictive factors associated with spontaneous regression. *European Radiology*. 27(6):2489-2496, 2017 Jun.

**63.** Yue SW, Guo H, Zhang YG, Gao JB, Ma XX, Ding PX. The clinical value of computer tomographic angiography for the diagnosis and therapeutic planning of patients with pulmonary sequestration. European Journal of Cardio-Thoracic Surgery. 43(5):946-51, 2013 May.

**64.** American College of Radiology. ACR Appropriateness Criteria® Radiation Dose Assessment Introduction. Available at: <https://edge.sitecorecloud.io/americanacoldf5f-acrorgf92a-productioncb02-3650/media/ACR/Files/Clinical/Appropriateness-Criteria/ACR-Appropriateness-Criteria-Radiation-Dose-Assessment-Introduction.pdf>.

## **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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