

# ACR Appropriateness Criteria<sup>®</sup> Right Lower Quadrant Pain—Suspected Appendicitis

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The diagnostic imaging of patients presenting with right lower quadrant pain and suspected appendicitis may be organized according to age and gender and to the presence or absence of “classic” signs and symptoms of acute appendicitis. Among adult patients presenting with clinical signs of acute appendicitis, the sensitivity and specificity of CT are greater than those of ultrasound, with improved performance when CT is performed with intravenous contrast. The use of rectal contrast has been associated with decreased time in the emergency department. Computed tomography has also been shown to reduce cost and negative appendectomy rates. Both CT and ultrasound are also effective in the identification of causes of right lower quadrant pain unrelated to appendicitis. Among pediatric patients, the sensitivity and specificity of graded-compression ultrasound can approach those of CT, without the use of ionizing radiation. Performing MRI after inconclusive ultrasound in pregnant patients has been associated with sensitivity and specificity of 80% to 86% and 97% to 99%, respectively. The ACR Appropriateness Criteria<sup>®</sup> are evidence-based guidelines for specific clinical conditions that are reviewed every 2 years by a multidisciplinary expert panel. The guideline development and review include an extensive analysis of current medical literature from peer-reviewed journals and the application of a well-established consensus methodology (modified Delphi) to rate the appropriateness of imaging and treatment procedures by the panel. In those instances in which evidence is lacking or not definitive, expert opinion may be used to recommend imaging or treatment.

**Key Words:** Appropriateness criteria, CT, ultrasound, appendicitis, abdominal pain, comparative studies

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## SUMMARY OF LITERATURE REVIEW

Few comparative imaging studies evaluating right lower quadrant pain are available. Most imaging reports center

on disease processes, such as appendicitis. Because appendicitis is the most common cause of right lower quadrant pain, the focus of this narrative is on appendicitis

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and the accuracy of imaging procedures in diagnosing appendicitis, although consideration of other diseases is of course included.

The topic of right lower quadrant pain, suspected appendicitis, has been organized into 4 variants: **Variant 1**: fever, leukocytosis, and classic presentation clinically for appendicitis in adults; **Variant 2**: fever, leukocytosis; possible appendicitis, atypical presentation, adults and adolescents; **Variant 3**: fever, leukocytosis, pregnant woman; and **Variant 4**: fever, leukocytosis, possible appendicitis, atypical presentation in children (aged <14 years).

Acute appendicitis is the most common acute abdominal disorder that requires surgery [1]. In most patients with acute appendicitis, imaging may not be necessary because the clinical presentation is sufficiently diagnostic to allow surgery [2]. Clinical prediction scores, such as the Alvarado score, have been used as a prediction rule for identifying patients with appendicitis. However, the accuracy of these clinically based scores is inferior to that of imaging [3]. In the published studies for imaging in appendicitis, the selection criteria for imaging are not often stated, but in most investigations, subjects with definitive clinical examination findings of appendicitis undergo operation without imaging. In the reported imaging studies, an average of 45% to 50% of imaged subjects had appendicitis, and 36% had nonspecific abdominal pain. Data on the overall effect of imaging on surgical treatment of appendicitis and patient outcome remain contradictory [4-12].

Radiographic diagnosis is of limited value for diagnosing acute appendicitis, except in occasional circumstances when an appendicolith or other ancillary findings are identified. Although barium enema has been used

historically to diagnose appendicitis, it depends on the negative finding of nonvisualization of the appendix and may be quite uncomfortable in patients with acute appendicitis. Nonetheless, barium small-bowel follow-through or barium enema may be useful after cross-sectional imaging studies for other causes of right lower quadrant pain, including suspected small-bowel obstruction, infectious ileitis, and inflammatory bowel disease. (See the ACR Appropriateness Criteria® on Suspected Small Bowel Obstruction [13].)

### CT and Ultrasound

CT is the most accurate study for evaluating patients without clear clinical diagnoses of acute appendicitis [14,15]. In a meta-analysis of 6 prospective studies through February 2006 of the accuracy of CT and ultrasound in adolescents and adults, CT demonstrated superior sensitivity (91%; 95% confidence interval [CI], 84%-95%) and specificity (90%; 95% CI, 85%-94%) compared with ultrasound (sensitivity, 78%; 95% CI, 67%-86%; specificity, 83%; 95% CI, 76%-88%) [16]. The results of investigations of CT showed consistent results across all studies and institutions, while ultrasound investigations demonstrated heterogeneity, suggesting greater dependence on operator skill [17]. Small studies suggest that thinner slices and multiplanar reformats increase confidence in identifying the appendix [18-20].

The routine use of CT to evaluate for appendicitis has also been shown to decrease overall costs by \$447 to \$1,412 per patient [11,21] and has been shown to decrease the negative appendectomy rate from 42.9% to 7.1% among women aged 18 to 45 years [22]. Although

#### Variant 1. Fever, leukocytosis, and classic presentation clinically for appendicitis in adults

Radiologic Procedure	Rating	Comments	Relative Radiation Level
CT abdomen and pelvis with contrast	8	Use of oral or rectal contrast depends on institutional preference.	☼☼☼☼
CT abdomen and pelvis without contrast	7	Use of oral or rectal contrast depends on institutional preference.	☼☼☼☼
Ultrasound abdomen RLQ	6	With graded compression.	0
Ultrasound pelvis	5		0
X-ray abdomen	5	May be useful in excluding free air or obstruction.	☼☼☼
MRI abdomen and pelvis with or without contrast	4	See statement regarding contrast in text under "Anticipated Exceptions."	0
X-ray contrast enema	3		☼☼☼
<sup>99m</sup> Tc WBC scan abdomen and pelvis	3		☼☼☼

Note: Rating scale: 1, 2, and 3 = usually not appropriate; 4, 5, and 6 = may be appropriate; 7, 8, and 9 = usually appropriate. RLQ = right lower quadrant; WBC = white blood cell.

**Variant 2.** Fever, leukocytosis; possible appendicitis, atypical presentation, adults and adolescents

Radiologic Procedure	Rating	Comments	Relative Radiation Level
CT abdomen and pelvis with contrast	8	Use of oral or rectal contrast depends on institutional preference.	☼☼☼☼
X-ray abdomen	6	May be useful in excluding free air or obstruction.	☼☼☼
Ultrasound abdomen RLQ	6	With graded compression.	0
Ultrasound pelvis	6		0
CT abdomen and pelvis without contrast	6	Use of oral or rectal contrast depends on institutional preference.	☼☼☼☼
MRI abdomen and pelvis with or without contrast	5	See statement regarding contrast in text under “Anticipated Exceptions.”	0
X-ray contrast enema	3	The relative radiation level for the adult procedure is ☼☼☼	☼☼☼☼
<sup>99m</sup> Tc WBC scan abdomen and pelvis	3		☼☼☼

Note: Rating scale: 1, 2, and 3 = usually not appropriate; 4, 5, and 6 = may be appropriate; 7, 8, and 9 = usually appropriate. RLQ = right lower quadrant; WBC = white blood cell.

it has been suggested that perhaps nonpregnant women of child-bearing age be worked up with a different imaging algorithm because of increased possibility of alternative diagnoses to appendicitis, such as gynecologic etiologies, no studies have directly addressed this issue to a sufficient degree. Clinical accuracy in diagnosing right lower quadrant pain in women of child-bearing age tends to be less accurate compared with adult men, thereby

suggesting a lower threshold for imaging in this population [23].

Another question is whether to use intravenous (IV) contrast in the CT evaluation of appendicitis. High accuracy has been reported for both techniques, but the few direct comparisons available in the literature suggest higher accuracy when IV contrast is used [24]. A prospective study with 232 patients showed that non-contrast-

**Variant 3.** Fever, leukocytosis, pregnant woman

Radiologic Procedure	Rating	Comments	Relative Radiation Level
Ultrasound abdomen RLQ	8	With graded compression. Better in first and early second trimester.	0
MRI abdomen and pelvis without contrast	7	May be useful following negative or equivocal ultrasound findings.	0
Ultrasound pelvis	6		0
CT abdomen and pelvis with contrast	6	Use of oral or rectal contrast depends on institutional preference.	☼☼☼☼
CT abdomen and pelvis without contrast	5	Use of oral or rectal contrast depends on institutional preference.	☼☼☼☼
X-ray abdomen	2		☼☼☼
X-ray contrast enema	2		☼☼☼
<sup>99m</sup> Tc WBC scan abdomen and pelvis	2		☼☼☼

Note: Rating scale: 1, 2, and 3 = usually not appropriate; 4, 5, and 6 = may be appropriate; 7, 8, and 9 = usually appropriate. RLQ = right lower quadrant; WBC = white blood cell.

**Variant 4. Fever, leukocytosis, possible appendicitis, atypical presentation in children (aged <14 years)**

Radiologic Procedure	Rating	Comments	Relative Radiation Level
Ultrasound abdomen RLQ	8	With graded compression.	0
CT abdomen and pelvis with contrast	7	May be useful following negative or equivocal ultrasound findings. Use of oral or rectal contrast depends on institutional preference. Consider limited RLQ CT.	☼☼☼☼
X-ray abdomen	6	May be useful in excluding free air or obstruction.	☼☼☼
Ultrasound pelvis	5		0
CT abdomen and pelvis without contrast	5	Use of oral or rectal contrast depends on institutional preference. Consider limited RLQ CT.	☼☼☼☼
MRI abdomen and pelvis with or without contrast	5	See statement regarding contrast in text under "Anticipated Exceptions."	0
X-ray contrast enema	3		☼☼☼☼
<sup>99m</sup> Tc WBC scan abdomen and pelvis	2		☼☼☼

Note: Rating scale: 1, 2, and 3 = usually not appropriate; 4, 5, and 6 = may be appropriate; 7, 8, and 9 = usually appropriate. RLQ = right lower quadrant; WBC = white blood cell.

enhanced CT (sensitivity, 90%; specificity, 86%) was inferior to rectal-only contrast (sensitivity, 93%; specificity, 95%) and IV and oral contrast (sensitivity, 100%; specificity, 89%) [25]. In lieu of individual patient contraindications to IV contrast, its use is recommended in the evaluation of right lower quadrant abdominal pain. However, if IV contrast is contraindicated, non-contrast-enhanced CT has been shown to have sensitivity of 96%, specificity of 99%, and accuracy of 97% [26].

Other questions regarding CT protocols include the use of oral vs rectal contrast. A recent study showed similar sensitivity and specificity for detection of acute appendicitis on 64-row multidetector CT with or without oral contrast performed with IV contrast [27]. The use of rectal contrast was shown to decrease the emergency department stay by >1 hour in one prospective study, without a significant difference in patient satisfaction or discomfort [28]. There is concern, however, that rectal contrast can be complicated by bowel perforation, with a cited number similar to barium enema of 0.04% [24]. To our knowledge, no prospective comparison studies evaluating the two are available in the literature. Institutional experience may be the best determinant of oral vs rectal contrast use.

Both CT and ultrasound may be effective in detecting causes of pain unrelated to appendicitis. The range of diseases studied includes inflammatory bowel disease, infectious bowel disease, small bowel obstruction, acute gynecologic conditions, and others.

CT seems superior to ultrasound in evaluating patients with periappendiceal abscess, especially when the abscesses become large [29]. CT can be used to choose

among different therapeutic options, including antibiotic treatment (with small abscesses), percutaneous drainage (with 1 to 3 well-defined medium-sized abscesses), and surgery (with extensive abnormality not amenable to percutaneous drainage) [30,31].

### MRI

At this time, there are few studies evaluating the value of MRI in the general population for acute appendicitis. MRI is desirable because of its lack of ionizing radiation, but it is limited because of its higher cost, slower acquisition time, and lesser clinical availability. Several small, retrospective studies cited sensitivity of 97% to 100% and specificity of 92% to 94% [32]; one prospective study of 138 patients exhibited sensitivity of 100% and specificity of 99% [33]. It is anticipated that as MRI becomes more clinically available in the emergency setting, the value of MRI for right lower quadrant pain will be further elucidated.

### Pediatric Patients

CT and US have been less well evaluated in children than in adults, but there are increasing data on imaging use in the pediatric population. Several factors are unique in children, including increased radiosensitivity to ionizing radiation and smaller body size and less body fat, favoring initial use of ultrasound. A systematic literature review in July 2004 revealed 8 prospective evaluations of ultrasound for appendicitis in children [34]. The pooled sensitivity of graded-compression ultrasound was 91% (95% CI, 89%-93%), and the specificity was 97% (95% CI, 95%-99%). A meta-analysis published in October

2006 included 26 studies of ultrasound and CT, 15 prospective and 11 retrospective, in the pediatric population. The pooled sensitivity of ultrasound was 88% (95% CI, 86%-90%), with specificity of 94% (95% CI, 92%-95%), compared with CT, which exhibited a pooled sensitivity of 94% (95% CI, 92%-97%) and specificity of 95% (95% CI, 94%-97%) [35]. These results suggest that although CT is more accurate, ultrasound is nearly as good in experienced hands and, given the lack of ionizing radiation, is the preferred examination in children, particularly if equivocal results are followed up by CT [36-40]. Thus the CT-after-ultrasound approach seems to have excellent accuracy, with reported sensitivity and specificity of 94% [41]. A single retrospective study showed that in children with intermediate to high pretest probability, ultrasound followed by CT is most cost effective, whereas in patients with low pretest probability, ultrasound alone is the most effective and least costly strategy [42]. If CT is performed, the use of IV contrast is recommended; however, the use of enteric contrast, such as oral or rectal contrast, has not been shown to significantly increase sensitivity in children and should be left to the discretion of the individual department and hospital policy [43]. The addition of multiplanar reformats, such as coronal images, was shown in a small study to increase reader confidence in identifying the appendix in its entirety and other periappendiceal findings and should be included in the CT protocol, particularly given that this does not require additional scanning and increased radiation dose to obtain [44]. Recently, nonvisualization of the appendix on normal CT has been shown to have a high negative predictive value of 98.7% (95% CI, 95.5%-99.8%) [45].

### Pregnant Patients

Since the last revision of these appropriateness criteria, evaluation of the accuracy of imaging in pregnant women has received more attention in the literature. In general, ionizing radiation from CT should be avoided during pregnancy. Ultrasound is clearly a safer imaging option and is the first imaging test of choice [46], although CT after equivocal ultrasound findings has been validated for diagnosis [47]. A systematic literature review through August 2008 addressed 8 retrospective studies of CT and MRI after negative or inconclusive ultrasound in pregnant women [48]. The pooled sensitivity of CT after ultrasound was 86% (95% CI, 64%-97%), and the specificity was 97% (95% CI, 86%-100%). MRI is the preferred test after inconclusive ultrasound findings, as new studies have shown comparable sensitivity and specificity with CT without exposing the fetus to ionizing radiation [49-51]. The pooled sensitivity of MRI after ultrasound was 80% (95% CI, 44%-98%), and the specificity was 99% (95% CI, 94%-100%). Although these findings suggest an imaging algorithm of ultrasound followed by MRI, if the initial ultrasound findings are inconclusive,

the detection of a normal appendix in pregnant patients has been shown to be as low as 2% [52].

### Nuclear Medicine

Nuclear medicine imaging with white blood cell scans has also been reported for evaluating right lower quadrant pain [53]. However, the sensitivity and specificity of nuclear scans for this indication have been shown to be significantly inferior to ultrasound, CT, and MR [54].

### SUMMARY

- Appendicitis may be diagnosed clinically, but imaging increases sensitivity and specificity for diagnosis.
- In general, CT is the most accurate imaging study for evaluating suspected appendicitis and alternative etiologies of right lower quadrant abdominal pain.
- In children, ultrasound is the preferred initial examination, as it is nearly as accurate as CT for diagnosis of appendicitis without exposure to ionizing radiation.
- In pregnant women, increasing data support the use of MR after equivocal or inconclusive ultrasound findings.

### ANTICIPATED EXCEPTIONS

Nephrogenic systemic fibrosis is a disorder with a scleroderma-like presentation and a spectrum of manifestations that can range from limited clinical sequelae to fatality. It seems to be related to both underlying severe renal dysfunction and the administration of gadolinium-based contrast agents. It has occurred primarily in patients on dialysis, rarely in patients with very limited glomerular filtration rates (ie,  $<30$  mL/min/1.73 m<sup>2</sup>), and almost never in other patients. There is growing literature regarding nephrogenic systemic fibrosis. Although some controversy and lack of clarity remain, there is a consensus that it is advisable to avoid all gadolinium-based contrast agents in dialysis-dependent patients unless the possible benefits clearly outweigh the risk and to limit the type and amount in patients with estimated glomerular filtration rates  $<30$  mL/min/1.73 m<sup>2</sup>. For more information, please see the ACR's *Manual on Contrast Media* [55].

### RELATIVE RADIATION LEVEL INFORMATION

Potential adverse health effects associated with radiation exposure are an important factor to consider when selecting the appropriate imaging procedure. Because there is a wide range of radiation exposures associated with different diagnostic procedures, a relative radiation level indication has been included for each imaging examination. The relative radiation levels are based on effective dose, which is a radiation dose quantity that is used to estimate population total radiation risk associated with an imaging procedure. Patients in the pediatric age group are at inherently higher risk from exposure, both because of organ sensitivity and longer life expectancy (relevant to

**Table 1.** Relative radiation level designations

Relative Radiation Level	Adult Effective Dose Estimate Range (mSv)	Pediatric Effective Dose Estimate Range (mSv)
0 ☼	0 <0.1	0 <0.03
☼☼	0.1–1	0.03–0.3
☼☼☼	1–10	0.3–3
☼☼☼☼	10–30	3–10
☼☼☼☼☼	30–100	10–30

Note: Relative radiation level assignments for some of the examinations cannot be made, because the actual patient doses in these procedures vary as a function of a number of factors (eg, region of the body exposed to ionizing radiation, the imaging guidance that is used). The relative radiation levels for these examinations are designated as not specified.

the long latency that appears to accompany radiation exposure). For these reasons, the relative radiation level dose estimate ranges for pediatric examinations are lower compared with those specified for adults (Table 1). Additional information regarding radiation dose assessment for imaging examinations can be found in *ACR Appropriateness Criteria<sup>®</sup>: Radiation Dose Assessment Introduction* [56].

For additional information on ACR Appropriateness Criteria, refer to <http://www.acr.org/ac>.

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