American College of Radiology
ACR Appropriateness Criteria®

Clinical Condition: **Right Lower Quadrant Pain — Suspected Appendicitis**

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

Radiologic Procedure	Rating	Comments	RRL*
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.	☢☢☢☢
US abdomen RLQ	6	With graded compression.	O
US pelvis	5		O
X-ray abdomen	5	May be useful in excluding free air or obstruction.	☢☢
MRI abdomen and pelvis without and with contrast	5	See statement regarding contrast in text under "Anticipated Exceptions."	O
CT abdomen and pelvis without and with contrast	4	Use of oral or rectal contrast depends on institutional preference.	☢☢☢☢
MRI abdomen and pelvis without contrast	4		O
X-ray contrast enema	3		☢☢☢
Tc-99m WBC scan abdomen and pelvis	3		☢☢☢☢
Rating Scale: 1,2,3 Usually not appropriate; 4,5,6 May be appropriate; 7,8,9 Usually appropriate			*Relative Radiation Level

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

Radiologic Procedure	Rating	Comments	RRL*
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.	☢☢
US abdomen RLQ	6	With graded compression.	O
US pelvis	6		O
CT abdomen and pelvis without contrast	6	Use of oral or rectal contrast depends on institutional preference.	☢☢☢☢
MRI abdomen and pelvis without and with contrast	5	See statement regarding contrast in text under "Anticipated Exceptions."	O
CT abdomen and pelvis without and with contrast	4	Use of oral or rectal contrast depends on institutional preference.	☢☢☢☢
MRI abdomen and pelvis without contrast	4		O
X-ray contrast enema	3	The RRL for the adult procedure is ☢☢☢.	☢☢☢☢
Tc-99m WBC scan abdomen and pelvis	3		☢☢☢☢
Rating Scale: 1,2,3 Usually not appropriate; 4,5,6 May be appropriate; 7,8,9 Usually appropriate			*Relative Radiation Level

Clinical Condition: **Right Lower Quadrant Pain — Suspected Appendicitis**

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

Radiologic Procedure	Rating	Comments	RRL*
US abdomen RLQ	8	With graded compression. Better in first and early second trimester.	O
MRI abdomen and pelvis without contrast	7	May be useful following negative or equivocal US.	O
US pelvis	6		O
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.	☢☢☢☢
CT abdomen and pelvis without and with contrast	5	Use of oral or rectal contrast depends on institutional preference.	☢☢☢☢
MRI abdomen and pelvis without and with contrast	4	See statement regarding contrast in text under "Anticipated Exceptions."	O
X-ray abdomen	2		☢☢
X-ray contrast enema	2		☢☢☢
Tc-99m WBC scan abdomen and pelvis	2		☢☢☢☢
Rating Scale: 1,2,3 Usually not appropriate; 4,5,6 May be appropriate; 7,8,9 Usually appropriate			***Relative Radiation Level**

Variant 4: **Fever, leukocytosis, possible appendicitis, atypical presentation in children (less than 14 years of age).**

Radiologic Procedure	Rating	Comments	RRL*
US abdomen RLQ	8	With graded compression.	O
CT abdomen and pelvis with contrast	7	May be useful following negative or equivocal US. 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.	☢☢
US pelvis	5		O
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 without and with contrast	5	See statement regarding contrast in text under "Anticipated Exceptions."	O
CT abdomen and pelvis without and with contrast	4	Use of oral or rectal contrast depends on institutional preference. Consider limited RLQ CT.	☢☢☢☢
MRI abdomen and pelvis without contrast	4		O
X-ray contrast enema	3		☢☢☢☢
Tc-99m WBC scan abdomen and pelvis	2		☢☢☢☢
Rating Scale: 1,2,3 Usually not appropriate; 4,5,6 May be appropriate; 7,8,9 Usually appropriate			***Relative Radiation Level**

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

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 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%-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 following 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.")

Computed Tomography and Ultrasound

Computed tomography (CT) is the most accurate study for evaluating patients without a clear clinical diagnosis of acute appendicitis [13-14]. In a meta-analysis of six prospective studies through February 2006 of the accuracy of CT and ultrasound (US) in adolescents and adults, CT demonstrated superior sensitivity (91%; 95% CI, 84%-95%) and specificity (90%; 95% CI, 85%-94%) versus US (sensitivity, 78%; 95% CI, 67%-86-%; specificity 83%, 95% CI, 76%-88%) [15]. The results of investigations of CT showed consistent results across all studies and institutions, while US investigations demonstrated heterogeneity, suggesting greater dependence on operator skill [16]. Small studies suggest that thinner slices and multiplanar reformats increase confidence in identifying the appendix [17-19].

The routine use of CT to evaluate for appendicitis has also been shown to decrease overall costs by $447 to $1,412 per patient [11,20], and has been shown to decrease the negative appendectomy rate from 42.9% to 7.1% among women aged 18-45 years [21]. While it has been suggested that perhaps nonpregnant females of child-bearing age be worked up with a different imaging algorithm due to increased possibility of alternative diagnoses to appendicitis, such as gynecological 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 [22].

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 [23]. A prospective study with 232 patients showed that

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noncontrast 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%) [24]. In lieu of individual patient contraindications to IV contrast, its use is recommended in evaluation of right lower quadrant abdominal pain. However, if IV contrast is contraindicated, noncontrast enhanced CT has been shown to have sensitivity of 96%, specificity of 99%, and accuracy of 97% [25].

Other questions regarding CT protocol include the use of oral versus rectal contrast. A recent study has shown similar sensitivity and specificity for detection of acute appendicitis on 64-row MDCT with or without oral contrast performed with intravenous contrast [26]. The use of rectal contrast has been shown to decrease the emergency department stay by greater than one hour in one prospective study, without a significant difference in patient satisfaction or discomfort [27]. There is concern, however, that rectal contrast can be complicated by bowel perforation, with a cited number similar to barium enema of 0.04% [23]. To our knowledge, no prospective comparison studies evaluating the two are available in the literature. Institutional experience may be the best determinant of oral versus rectal contrast use.

Both CT and US 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 gynecological conditions, and others.

CT appears superior to US in evaluating patients with periappendiceal abscess, especially when the abscesses become large [28]. CT can be used to choose among different therapeutic options, including antibiotic treatment (with small abscesses), percutaneous drainage (with one to three well-defined medium-sized abscesses), and surgery (with extensive abnormality not amenable to percutaneous drainage) [29-30].

Magnetic Resonance Imaging

At this time, there are few studies evaluating the value of magnetic resonance imaging (MRI) in the general population for acute appendicitis. MRI is desirable due to its lack of ionizing radiation; however, it is limited due to its higher cost, slower acquisition time, and lesser clinical availability. Several small, retrospective studies cite sensitivity of 97%-100% and specificity of 92%-94% [31]; one prospective study of 138 patients exhibited a sensitivity of 100% and specificity of 99% [32]. 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 US. A systematic literature review in July 2004 revealed eight prospective evaluations of US for appendicitis in children [33]. The pooled sensitivity of graded-compression US 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 US and CT — 15 prospective and 11 retrospective, in the pediatric population. The pooled sensitivity of US was 88% (95% CI, 86%-90%) and 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%) [34]. These results suggest that although CT is more accurate, US 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 [35-39]. Thus the CT- after US-approach appears to have excellent accuracy, with reported sensitivity and specificity of 94% [40]. A single retrospective study showed that in intermediate-to-high pretest probability children, US followed by CT is most cost-effective, whereas, in low pretest probability patients, US alone is the most effective and least costly strategy [41]. If CT is performed, the use of intravenous 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 [42]. Addition of multiplanar reformats, such as coronal images, has been 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, as this does not require additional scanning and increased radiation dose to obtain [43]. Recently, nonvisualization of the appendix on a normal CT has been shown to have a high negative predictive value — 98.7% (95% CI, 95.5%, 99.8%) [44].

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. US is clearly a safer imaging option and is the first imaging test of choice [45], although CT after equivocal US has been validated for diagnosis [46]. A systematic literature review through August 2008 addressed eight retrospective studies of CT and MRI after negative or inconclusive US in pregnant women [47]. The pooled sensitivity of CT after US was 86% (95% CI, 64%-97%), and the specificity was 97% (95% CI, 86%-100%). MRI is the preferred test after inconclusive US, as new studies have shown a comparable sensitivity and specificity with CT without exposing the fetus to ionizing radiation [48-50]. The pooled sensitivity of MRI after US was 80% (95% CI, 44%-98%) and the specificity was 99% (95% CI, 94%-100%). Although these findings suggest an imaging algorithm of US followed by MRI, if the initial US is inconclusive, the detection of a normal appendix in pregnant patients has been shown to be as low as 2% [51].

Nuclear Medicine

Nuclear medicine imaging with WBC scans has also been reported for evaluating right lower quadrant pain [52]. However, the sensitivity and specificity of nuclear scans for this indication have been shown to be significantly inferior to US, CT, and MR [53].

Summary

- Appendicitis may be diagnosed clinically; however, 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, US 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 US.

Safety Considerations in Pregnant Patients

Imaging of the pregnant patient can be challenging, particularly with respect to minimizing radiation exposure and risk. For further information and guidance, see the following ACR documents:

- ACR Practice Guideline for Imaging Pregnant or Potentially Pregnant Adolescents and Women with Ionizing Radiation
- ACR-ACOG-AIUM Practice Guideline for the Performance of Obstetrical Ultrasound
- ACR Manual on Contrast Media
- ACR Guidance Document for Safe MR Practices

Anticipated Exceptions

Nephrogenic systemic fibrosis (NSF) is a disorder with a scleroderma-like presentation and a spectrum of manifestations that can range from limited clinical sequelae to fatality. It appears 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 rate (GFR) (ie, <30 mL/min/1.73m^2), and almost never in other patients. There is growing literature regarding NSF. 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 GFR rates <30 mL/min/1.73m^2. For more information, please see the ACR *Manual on Contrast Media* [54].

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, both because of 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 to 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
O	0 mSv	0 mSv
☢	<0.1 mSv	<0.03 mSv
☢ ☢	0.1-1 mSv	0.03-0.3 mSv
☢ ☢ ☢	1-10 mSv	0.3- 3 mSv
☢ ☢ ☢ ☢	10-30 mSv	3-10 mSv
☢ ☢ ☢ ☢ ☢	30-100 mSv	10-30 mSv

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

Supporting Document(s)

- ACR Appropriateness Criteria® Overview
- Procedure Information
- Evidence Table

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