



Imaging the Appendix: What to Order and When to Order It

Ruling out appendicitis remains a challenge for emergency physicians. Several imaging modalities are available to help resolve this dilemma, but each has significant limitations. This lecture will review the various tests, including computed tomography, ultrasound, and laparoscopy, and identify their strengths and weaknesses. The lecturer will identify clinical situations in which these tests may be indicated in both adults and children.

- Identify imaging studies that can help rule out appendicitis.
- Discuss the strengths and weaknesses of each modality.
- Describe clinical scenarios in which each test may be indicated.

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FACULTY

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IMAGING THE APPENDIX: WHAT TO ORDER & WHEN TO ORDER IT

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I. Course Description

Evaluating the patient suspected of having appendicitis can be challenging. Historically, the clinical impression of physician, even with the aid of laboratory tests, has been only moderately accurate in diagnosing appendicitis. This course will review the utility of the following imaging modalities in the evaluation of appendicitis: plain radiography, barium enema, nuclear medicine scanning, ultrasound, CT and laparoscopy.

II. Course Outline

A. Appendicitis: Facts and Figures

1. Common: 250,000 appendectomies/year in U.S.
2. Physician accuracy in clinically diagnosing appendicitis poor (70-85% accuracy)
 - ◆ Clinical diagnosis sensitivity = 50–78%, specificity = 58-95%
 - ◆ Historic negative appendectomy rates:
 - Overall: 15-20%
 - Males: 10%
 - Menstruating females: 25-45%
 - ◆ Delayed diagnosis increases perforation risk
 - With perforation mortality increases from 0.1% to 5%.
 - Typical perforation rate at time of appendectomy = ~20%.

B. Plain Radiographs

1. Radiographic findings with appendicitis
 - ◆ Appendicolith (seen in 10% appendicitis patients)
 - ◆ RLQ soft tissue mass
 - ◆ Focal RLQ ileus (sentinel loop)
 - ◆ Free intraperitoneal air
 - ◆ Gas in the appendix
2. Role in Appendicitis
 - ◆ Plain film accuracy:
 - Sensitivity = 20%
 - Specificity = 99%
 - Accuracy = 57% (Galindo Gallego et al, 1998)
 - ◆ More helpful in identifying other causes of abdominal pain (i.e. SBO, volvulus)

3. Conclusion
 - ◆ Not recommended for suspected appendicitis

C. Barium Enema

1. Radiographic findings with appendicitis
 - ◆ Nonfilling of the appendix
 - ◆ Extrinsic mass effect on cecum
2. Role in Appendicitis
 - ◆ Sensitivity ~80%, specificity ~95%
 - ◆ Nonfilling occurs in 10% normals and filling occurs in 20% nongangrenous appendicitis
 - ◆ Uncomfortable, technical failures common
 - ◆ No information on disease outside bowel
3. Conclusion: rarely, if ever, used today

D. Nuclear Medicine Imaging

1. Findings; increased uptake in RLQ
 - ◆ Can take several hours to perform
 - ◆ Most studies utilize technetium 99m labeled WBC's
2. Accuracy:

<u>Author</u>	<u>(N)</u>	<u>Sensitivity (%)</u>	<u>Specificity (%)</u>	<u>Accuracy (%)</u>	<u>Agent</u>
Kanegaye '95	23	43	47	46	TC-99 WBC
Biersack '93	32	71	73	72	TC-99 antibodies
Foley '92	30	81	100	89	TC-99 WBC
Evetts '94	37	85	93	89	TC-99 WBC
Navarro '87	32	86	93	91	Indium-III WBC
Wong '97	35	91	100	94	TC-99 WBC
Lin '97	49	92	92	92	TC-99 WBC
Kao '96	50	93	90	92	TC-99 WBC
Rypins '97	100	97	94	95	TC-99 WBC
Rypins '97	124	98	85	90	TC-99 WBC

Table 1. Study results of nuclear medicine imaging in appendicitis.

- ◆ Wide range of results:
 - Sensitivities = 43-98%
 - Specificities = 47-100%
 - Accuracies = 46-95%
 - ◆ Most studies small (N<50)
 - ◆ Poor interrater reliability
3. Conclusion:

- ◆ Considering
 - Technical difficulties
 - Time requirements (often >4 hours)
 - Little data
 - More readily available options
 - Poor interrater reliability
 - Inconsistent accuracy
- ◆ Nuclear imaging has little current role in appendicitis

E. Ultrasound Imaging

1. Ultrasound Findings in Appendicitis

Noncompressible appendix >6mm in diameter*

or

Presence of complex mass

or

Presence of an appendicolith

*primary finding

- ◆ Technique involves graded compression of the RLQ with 5-7.5 MHz probe to displace bowel gas
- ◆ Normal appendix visualized in 2%-82%!

2. Role in Appendicitis

- ◆ Dozens of studies have been published
- ◆ Can provide information on other diagnoses (i.e. urolithiasis, ovarian pathology)
- ◆ It is a technically challenging, operator-dependent study

<u>Author</u>	<u>Year</u>	<u>(N)</u>	<u>Sensitivity (%)</u>	<u>Specificity (%)</u>	<u>Accuracy (%)</u>
Skaane	1997	126	36	88	64
Jahn	1997	222	49	88	72
John	1993	111	78	73	76
Skaane	1990	240	78	92	87
Zielke	1998	669	80	97	93
Gallego	1998	192	82	96	88
Ooms	1991	525	87	99	94
Ramachandran*	1996	452	90	96	95
Hahn*	1998	3859	90	97	96
Schwerk	1990	857	90	98	96
Rioux	1992	170	93	94	94
Chen	1998	191	99	68	92

*pediatric studies

Table 2. Results of the largest ultrasound studies for appendicitis in the last decade.

- ◆ U/S improves accuracy compared with clinical impression alone.

- Zielke et al, 1997. N=504, prospective study.

	<u>Sensitivity (%)</u>		<u>Specificity (%)</u>	<u>Accuracy (%)</u>
Clinical diagnosis	51	95	85	
Ultrasound	83		97	94
Combination	84		96	93

- Wade et al, 1993. N=110, prospective study.

	<u>Sensitivity (%)</u>		<u>Specificity (%)</u>	<u>Accuracy (%)</u>
Clinical diagnosis	63	82	71	
Ultrasound	86		84	85

- ◆ The impact of ultrasound depends on the pretest probability of having appendicitis
 - Meta-analysis of 3,358 patients/17 studies (Orr et al, 1995)
 - Overall results

Sensitivity	Specificity
85%	92%
 - Subgroup analysis based on clinical likelihood of appendicitis:

<u>Clinical Probability</u>	<u>PPV (%)</u>	<u>NPV (%)</u>	<u>Accuracy (%)</u>
High probability	98	60	86
Intermediate probability	87	90	89
Low probability	20	100	92

- ◆ Therefore
 1. U/S cannot accurately rule out appendicitis when clinical likelihood of appendicitis is high
 2. Positive U/S not helpful in low risk patients
 3. U/S most helpful in indeterminate cases
- 3. Conclusion
 - ◆ Ultrasound in the evaluation of appendicitis has good (not great) accuracy, that will be dependent on institutional experience
 - ◆ Most helpful in clinically indeterminate patients

F. Spiral CT Imaging

1. CT findings in appendicitis

- ◆ Many findings have been described, the primary findings are:
 - Enlarged appendix (diameter >6mm)
 - Periappendiceal inflammatory changes

2. Scan Technique

- ◆ Studies have varied with regard to the use of contrast enhancement (IV, oral, rectal, any combination of these 3 or none at all). (See Table 3). Thin (5mm) sections.
- ◆ No prospective study has compared accuracy of sCT with and without contrast

3. Role in Appendicitis

a. Accuracy

- Impressive results. . .

<u>Author</u>	<u>(N)</u>	<u>Sensitivity (%)</u>	<u>Specificity (%)</u>	<u>Accuracy (%)</u>	<u>Contrast</u>
Lane '97	109	90	97	94	none
Balthazar '98	146	97	97	97	po, iv
Funaki '98	100	97	94	95	pr, po
Rao '97	100	98	98	98	pr
Schuler '98	97	98	91	96	po, iv
Rao '97	100	100	95	98	pr, po
Choi '98	124	100	92	99	iv, po

Table 3. Results of spiral CT studies evaluating possible appendicitis.

- ◆ But, will sCT do as well in community hospital setting as it did in university settings?
- ◆ Funaki et al, 1998. N=100, prospective study
 - All unequivocal cases went directly to surgery
 - One of 11 community hospital general radiologists read CT
 - None had prior experience with appendiceal CT
 - Results:
 - Sensitivity = 97%
 - Specificity = 94%
 - Accuracy = 95%
- b. Ability to Make Alternative Diagnoses
 - ◆ sCT often provides alternative diagnosis when patient does not have appendicitis

<u>Author</u>	<u>(N)</u>	<u>Alternative dx (%)</u>
Balthazar '98	146	26
Lane '97	109	34
Schuler '98	97	36
Funaki '98	100	54
Rao '97	100	62
Rao '97	100	80

Table 4. Percentages of patients in whom alternative diagnosis is made by spiral CT when appendicitis is not identified.

c. Cost-effectiveness

- ◆ Schuler et al, (1998) found in a cost analysis that it was cost effective to obtain sCT in patients suspected of appendicitis if the institutional negative appendectomy rate is $\geq 13\%$, given the expense involved in performing an unnecessary laparotomy.
- ◆ Rao et al, (NEJM, 1998) reported that scanning all patients suspected of having appendicitis saved their institution \$447/patient.

4. sCT compared with U/S

- ◆ sCT not impeded by obesity
- ◆ sCT more often identifies alternative pathology
- ◆ sCT completed more rapidly
- ◆ sCT provides more consistent results
- ◆ sCT has better accuracy

5. Conclusion

- ◆ sCT excellent test to diagnose appendicitis
- ◆ Not necessary in all patients (i.e., very high or very low clinical probability)

G. Laparoscopy

1. Laparoscopic finding: visualization of inflamed appendix allows for diagnosis of appendicitis
2. Clinical Application of Laparoscopy in Possible Appendicitis
 - a. Should normal appearing appendix be left in place?
 - ◆ At least 4 studies support this as being a safe approach
 - ◆ Others suggest removing appendix to prevent future appendicitis

b. Role of Laparoscopy in Appendicitis

- ◆ Advantages compared with open laparotomy
 - Smaller scar
 - Decreased post-operative pain
 - More rapid return to normal activities
- ◆ Disadvantages of laparoscopy
 - More expensive (one center laparoscopy = \$5400 vs. \$3200 for open appendectomy)
 - Appendix visualization impossible in 7-28%
 - 20-40% converted to open to complete case
- ◆ Still requires:
 - General anesthesia
 - Operating room
 - Contraindicated in:
 - Previous laparotomy
 - Obesity
 - Intestinal adhesions
- ◆ Has been shown to decrease appendectomy rates
 - Borgstein et al, (1997). 161 fertile women with RLQ pain studied- negative appendectomy rate decreased from 38% → 5% with laparoscopy.

3. Conclusion

- ◆ Minimally invasive
- ◆ Expensive
- ◆ Surgeon will make the call on approach (open laparotomy vs. laparoscopy)

H. MRI

1. MRI Findings

- ◆ Curved, fluid-filled, blind-ending structure
- ◆ Thickened, markedly enhancing wall

2. Role in Appendicitis

- ◆ Very little data to date
- ◆ Preliminary results encouraging
- ◆ Unlikely to be widely used due to
 - Cost
 - Scanning time
 - Lack of immediate, 24 hour availability
 - Other great tests exist (e.g. sCT)

III. Summary

- ◆ Approximately 15-20% of appendectomies are unnecessary.
- ◆ A delay in diagnosing appendicitis is associated with increased morbidity and mortality.
- ◆ When evaluating patients suspected of having appendicitis, emergency physicians should use imaging modalities based on a thorough understanding of the usefulness and limitations of these tests.

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