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Review

A systematic review of whether oral contrast is necessary for the computed tomography diagnosis of appendicitis in adults

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Abstract

Background: There are several methods of contrast administration when performing computed tomography (CT) scanning for suspected appendicitis. In this systematic review we evaluated the diagnostic performance of CT with and without contrast material.
Methods: Twenty-three reports were identified using a Medline search.
Results: The aggregated diagnostic performance characteristics of all modes of CT scanning were excellent with a range of sensitivity (83–97%), specificity (93–98%), positive predictive value (86–98%), negative predictive value (94–99%), and accuracy (92–97%). The diagnostic performance of CT without oral contrast was similar (sensitivity, 95% vs. 92% [not statistically significant]; negative predictive value, 96% for both protocols) or surprisingly better (specificity, 97% vs. 94%; positive predictive value, 97% vs. 89%; accuracy, 96% vs. 92%; $P < .0001$) than with oral contrast.
Conclusions: Noncontrast CT techniques to diagnose appendicitis showed equivalent or better diagnostic performance compared with CT scanning with oral contrast. A prospective comparative trial of CT with and without oral contrast for appendicitis should be performed to assess the adequacy of this modality.

Keywords: Appendicitis; Computed tomography; Sensitivity and specificity; Contrast media

More than 250,000 appendectomies are performed in the United States each year, making it the most commonly performed emergency abdominal procedure [1]. Early intervention to avoid perforation is the standard of care. The diagnosis of appendicitis is established by a combination of clinical, laboratory, and radiographic features, and should be recognized promptly to relieve patient discomfort and prevent perforation associated with diagnostic delay. Diagnosis error such as missed appendicitis resulting in perforation is one of the leading reasons for litigation against physicians [2], and although perforation is a result of one type of misdiagnosis, the other occurs when a patient is presumed to have appendicitis but is found at surgery to have a normal appendix, a so-called *negative appendectomy*.

In the general population undergoing appendectomy the rate of negative appendectomy is 15%, and may be as high as 25% in women of reproductive ages [3]. Reducing negative appendectomy without increasing the perforation rate might be expected to avoid unnecessary appendectomies and subsequent complications. Computed tomography (CT) scanning of the abdomen has been suggested to reduce negative appendectomy and has been reported to have high sensitivity, specificity, positive predictive value (PPV), and negative predictive value (NPV) [4–26]. At least 5 methods of CT scanning for the diagnosis of appendicitis have been reported including CT with rectal contrast, oral contrast, rectal and oral contrast, oral and intravenous (IV) contrast, and no contrast. The time to perform a scan varies significantly between these different methods of CT scanning. The administration of oral contrast is often the rate-limiting step, sometimes delaying surgery by several hours [1,27].

Given several reports of high sensitivity when contrast was not used, this study was conceived to evaluate the use of contrast scanning in patients with suspected appendicitis. If the faster CT scanning method (without oral contrast) has comparable diagnostic ability with the protocol involving oral contrast this may be an opportunity for quality improvement in the diagnosis of appendicitis.

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Methods

A MEDLINE search was performed using the MeSH terms: "Tomography, X-Ray Computed" [MAJR] AND "Appendicitis" [MAJR]. This search strategy yielded 189 articles. All 189 articles were reviewed to see if they met inclusion criteria. Inclusion criteria were as follows: prospective or retrospective studies examining adults over 16 years of age; the study must assess CT scan for diagnosis of appendicitis; the study must report sensitivity/specificity, PPV/NPV, or provide data to calculate these values; and the study must use a consistent mode of contrast or separate different modes. Exclusion criteria were studies involving children or women only, or no explicit specification of mode of contrast enhancement. Case reports, abstracts only, letters, and incomplete reports were excluded. Nineteen articles were not available in English. Of the remaining 170 reports, 4 were not related to the topic (3 on epiploic appendicitis, 1 on superior mesenteric vein thrombosis), 18 were in children only, 3 were in women only, and 50 were case presentations, comments, letters, and discussions of data previously presented. Nine articles were reviews that presented no new data. Fifty-eight did not allow for an assessment of the sensitivity/specificity of contrast in diagnosing appendicitis. Five were excluded because they did not separate results based on contrast type, leaving 23 retrospective and prospective studies. The references from these 23 studies were cross-checked and no additional studies were identified.

Reports detailing diagnostic results in patients with presumed appendicitis who were CT scanned using 1 of the 5 different protocols (rectal only, oral only, rectal and oral, IV and oral, and no contrast) were aggregated by protocol type. Data were compiled to generate an aggregated sensitivity, specificity, PPV, and NPV for each of the 5 protocols. Individual radiologic criteria used by investigators to establish the diagnosis of appendicitis were not evaluated, and only final diagnostic results were used in the data aggregation. The data were aggregated further into 2 groups: studies using oral contrast and studies without oral contrast. Sensitivity, specificity, PPV, and NPV of oral and nonoral contrast studies were compared using the chi-square test for comparisons. A P value of less than .05 was considered statistically significant (STATA Version 7, STATACorp, College Station, TX).

Results

Of the 23 studies, 83% (19 of 23) were prospective. Individual results of 3,474 patients (mean age, 32.9 ± 13.6 years, 54.1% female) undergoing CT scanning for suspected appendicitis were recorded. In all studies the CT scan results were confirmed by either pathologic findings or by clinical follow-up evaluation. The aggregate sensitivity, specificity, PPV, NPV, and accuracy are summarized by mode of CT scanning (Table 1). The aggregated specificity and NPV between all modes of CT scanning were similar (specificity range, 95–98%; NPV range, 94–99%). There was a greater range of values in sensitivity (83–97%) and PPV (86–98%) between modes of CT scanning.

The reported aggregated results of CT scans without oral contrast actually showed greater specificity, PPV, and accuracy, and the same rate of sensitivity and NPV when compared with any modality of CT scanning that involved oral contrast (Table 2). The performance characteristics with the greatest differences were PPV (89% for oral contrast, 97% without contrast, $P < .01$), specificity (94% for oral contrast, 97% without contrast, $P < .01$), and accuracy (92% for oral contrast, 96% without contrast, $P < .01$).

Comments

The rate of negative appendectomy and perforated appendicitis has not changed over the past decade [3]. This is surprising in light of the introduction of CT during a similar time period and multiple reports of high diagnostic accuracy. One explanation for this lack of impact on the rate of negative appendectomy is that the scans are not as accurate in practice as they are in the research environment [28]. Another explanation is that these tests may be underused because of clinical practice patterns, cost, or inconvenience [29]. A recent study of the Group Health Cooperative experience with appendectomy over 20 years indicates that as late as 2000 only 20% of patients undergoing appendectomy had a preoperative CT scan (Flum, unpublished data). A contributing factor to the low rates of CT scanning may be that the most prevalent method of CT involves the use of oral contrast. Oral contrast often is tolerated poorly and may delay treatment [1,27], and, although it may be the most common protocol used, a national standard has yet to be established. In this systematic review we found that the reported aggregated results of all modes of CT scanning were high. The range of sensitivity (83–97%), specificity (93–98%), PPV (86–98%), and NPV (94–99%) indicate that in centers reporting their results, CT performed well with all different methods. Importantly, the diagnostic performance of CT without oral contrast was as good (sensitivity, NPV) or surprisingly better (specificity, PPV, and accuracy) than CT with oral contrast.

The theoretic advantage of oral contrast is that it opacifies the cecum, allowing for the assessment of appendiceal obstruction. The drawbacks of oral contrast are that the patient must drink the contrast (or have it administered through a nasogastric tube), requiring 45 to 60 minutes to reach the cecum after ingestion, thereby increasing the scan time to 1 to 2 hours [9,10,14]. Oral contrast also can be difficult for nauseated patients, resulting in further delays if the contrast is vomited or fails to reach the appendix because of ileus. Rectal contrast also functions by opacifying the cecum. The advantage of rectal contrast administration is that it decreases the time from administration to scan

Table 1
Diagnostic performance of CT scanning protocols

Study	Sensitivity	Specificity	PPV	NPV	Accuracy	N	Design
Rectal contrast							
Wong et al 2002 [4]	95% (35/37)	92% (12/13)	97% (35/36)	86% (12/14)	94% (47/50)	50	Prospective
Pickuth and Spidmann 2001 [5]	95% (88/93)	89% (24/27)	97% (88/91)	83% (24/29)	93% (112/120)	120	Prospective
Walker et al 2000 [6]	94% (30/32)	100% (25/25)	100% (30/30)	93% (25/27)	96% (55/57)	57	Prospective
Rao et al 1997 [26]	100% (56/56)	93% (41/44)	95% (56/59)	100% (41/41)	97% (97/100)	100	Prospective
Holloway et al 2003 [8]	97% (226/232)	98% (188/191)	99% (226/229)	97% (188/194)	97% (414/423)	423	Prospective
Total	97% (435/450)	97% (290/300)	98% (435/445)	95% (290/305)	97% (725/750)	750	
Oral contrast							
Wijentunga et al 2001 [9]	93% (28/30)	97% (68/70)	93% (28/30)	97% (68/70)	96% (96/100)	100	Prospective
Jacobs et al 2001 [10]*	76% (39/51)	94% (150/159)	81% (39/48)	93% (150/162)	90% (189/210)	210	Prospective
Total	83% (67/81)	95% (218/229)	86% (67/78)	94% (218/232)	92% (285/310)	310	
Rectal and oral contrast							
Rao et al 1997 [7]	95% (56/59)	100% (41/41)	96% (56/58)	100% (41/41)	97% (97/100)	100	Prospective
Funaki et al 1998 [11]	97% (29/30)	94% (66/70)	88% (29/33)	99% (66/67)	95% (95/100)	100	Prospective
Total	95% (85/89)	96% (107/111)	93% (85/91)	99% (107/108)	96% (192/200)	200	
Oral and IV contrast							
Stroman et al 1999 [12]	92% (33/36)	85% (60/71)	75% (33/44)	95% (60/63)	87% (93/107)	107	Prospective
Schuler et al 1998 [13]	98% (49/50)	91% (43/47)	92% (49/53)	98% (43/44)	95% (92/97)	97	Retrospective
Ujiki et al 2002 [14]	90% (28/31)	89% (64/72)	78% (28/36)	95% (64/67)	89% (92/103)	103	Retrospective
Kamel et al 2000 [15]	96% (23/24)	100% (76/76)	100% (23/23)	99% (76/77)	99% (99/100)	100	Retrospective
Balthazar et al 1991 [16]	98% (56/57)	88% (29/33)	93.4% (56/60)	96.7% (29/30)	85% (85/100)	100	Prospective
Hershko et al 2002 [17]	90% (67/74)	98% (120/123)	96% (67/70)	94% (120/127)	95% (187/197)	197	Prospective
Jacobs et al 2001 [10]*	90% (46/51)	95% (151/159)	85% (46/54)	97% (151/156)	94% (197/210)	210	Prospective
Total	93% (302/323)	93% (543/581)	89% (302/340)	96% (543/564)	92% (845/914)	914	
No contrast							
Peck et al 2000 [18]	93% (103/111)	99.6% (252/253)	99% (103/104)	97% (252/260)	98% (355/364)	364	Retrospective
Lane et al 1997 [19]	90% (37/41)	97% (66/68)	95% (37/39)	94% (66/70)	94% (103/109)	109	Prospective
Malone et al 1993 [20]	87% (65/75)	97% (132/136)	94% (65/69)	93% (132/142)	93% (197/211)	211	Prospective
Ege et al 2002 [21]	96% (104/108)	98% (185/188)	97% (104/107)	98% (185/189)	98% (289/296)	296	Prospective
D'Lppolito et al 1998 [22]	91% (40/44)	100% (8/8)	100% (40/40)	67% (8/12)	92% (48/52)	52	Prospective
Horton et al 2000 [23]	97% (37/38)	100% (11/11)	100% (37/37)	92% (11/12)	98% (48/49)	49	Prospective
Lane et al 1999 [24]	96% (110/115)	98% (181/185)	96% (110/114)	98% (181/186)	97% (291/300)	300	Prospective
Morris et al 2002 [25]	97% (38/39)	91% (82/90)	83% (38/46)	99% (82/83)	93% (120/129)	129	Retrospective
Total	93% (534/571)	98% (917/939)	96% (534/556)	96% (917/954)	96% (1451/1510)	1510	

* Included both oral and oral with IV protocols. Data were added in the appropriate sections.

compared with oral contrast (average, 15–20 minutes) [4]. Rectal contrast requires rectal catheterization, an uncomfortable procedure for many patients and radiology technicians [30]. Failure of rectal contrast to reach the cecum also has been reported in as many as 18% [31], and the increased hydrostatic pressure in the colon from rectal contrast has the theoretical risk for increasing appendiceal perforation [9]. In this review, when enteral contrast was used the rectal contrast mode had the highest sensitivity, specificity, PPV, and accuracy.

IV and oral contrast is the most common technique used for abdominal CT [21]. It has been proposed that IV contrast enhancement of the wall of an inflamed appendix helps the radiologist diagnose appendicitis [31]. Another advantage is that the IV contrast aids in completely evaluating the abdomen for other pathology [14]. One study compared oral with oral and IV contrast and found that the combination of oral and IV contrast was superior [10]. Disadvantages of IV contrast include exacerbation of renal insufficiency in patients with renal damage and anaphylactic reactions in patients with contrast allergy [21].

In this review, noncontrast abdominal CT scans showed

Table 2
Diagnostic performance of CT with and without oral contrast

	Sensitivity	Specificity	PPV	NPV	Accuracy
Oral contrast (oral alone, oral + rectal, oral + IV)	92% (454/493)	94% (868/921)	89% (455/509)	96% (868/904)	92% (1322/1424)
No oral contrast (noncontrast and rectal only)	95% (969/1021)	97%* (1207/1239)	97%* (969/1001)	96% (1207/1259)	96%* (2176/2260)

* $P < .001$.

the highest sensitivity, specificity, PPV, and NPV of all modalities. The advantage of unenhanced CT is decreased scanning time (average scan time, 5–10 minutes [20,21]) compared with 1 to 2 hours for CT scans using oral contrast [9,10,14]. These scans also may have a lower cost than contrast CT because of staffing requirements required when administering IV contrast [21]. Patients may be more likely to prefer this type of scan because they are not required to consume contrast while nauseated, endure rectal catheterization, or IV placement [18]. A limiting factor to noncontrast scans is that in thinner patients the lack of significant retroperitoneal fat may make identification of the appendix and surrounding inflammation difficult without oral or IV contrast [19]. In addition, scans without contrast might miss other nonappendiceal pathology that might help explain the source of the patient's pain when the diagnosis is not appendicitis. These findings suggest that broader use of CT without oral contrast may be a useful approach to overcome one barrier to the use of diagnostic imaging in patients with suspected appendicitis. The accuracy of noncontrast CT scans at each center should be reviewed periodically to determine center-specific results and treatment protocols. If the accuracy of CT scanning at an individual center is not adequate then there may be no role for CT scanning of any type.

This review has several limitations. Studies that were included varied in design, inclusion and exclusion criteria, CT scanning technique (ie, helical or sequential scanners), radiologic criteria used to diagnose appendicitis, and scan fields. Furthermore, the finding that unenhanced CT had superior diagnostic accuracy compared with scans performed with oral contrast confounds conventional wisdom. This finding may be related to publication bias, in which the best centers publish their best or selection bias. For example, centers that report results of noncontrast CT already may have become expert at scan interpretation in prior years using contrast. Interpreters of noncontrast CT scans therefore may be more skilled than their less-experienced colleagues. To address this we considered the hospital characteristics of the reported studies. We found that of the studies reporting results of CT with oral contrast ($n = 11$), 6 (54%) were performed at academic centers with 30% accepting resident interpretations compared with the studies performed without oral contrast ($n = 13$), of which only 5 (38%) were performed at academic centers and only 8% allowed resident interpretations. This suggests that academic centers did not report more noncontrast studies but does not exclude the possibility that trainees were interpreting contrast scans more often than noncontrast scans. Patient selection also may be a factor in these findings because 70% of reports detailing the results of CT with oral contrast included patients with atypical presentation whereas only 42% of those reporting noncontrast CT included patients with atypical presentations. Lastly, helical scanners were introduced later in the experience with CT in appendicitis and this may act as a confounder in the finding that noncontrast scans have improved results. This selection bias may be linked to the unexpected finding that CT results without oral contrast were better than contrast scans. We did attempt to control for the issue of helical scanners and found that 85% (11 of 13) of the noncontrast results were performed on helical scanners compared with 82% (9 of 11) of scans using oral contrast. The results did not change significantly when only helical CT scans were included in the analysis.

In conclusion, this review showed that the quicker and less-burdensome, noncontrast CT scanning technique to diagnose appendicitis has similar and perhaps better diagnostic performance compared with CT scanning with oral contrast. Because of likely selection biases in these reports and an unclear translation of this technique from the research environment to the community at large, this finding should be studied further at individual centers and then in prospective comparative trials. If confirmed as an adequate study modality, noncontrast CT scanning should be used more commonly. Ultimately, the increased use of a highly diagnostic and timely intervention should decrease the rate of negative appendectomy. A cost-effectiveness evaluation also should be performed to determine if the increased use of CT without oral contrast is a worthwhile health care intervention.

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