ORAL CONTRAST IN DIAGNOSING ACUTE APPENDICITIS WITH CT SCAN; IS IT NECESSARY?

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Abstract:

Background: The diagnosis of acute appendicitis clinically is challenging due to variant age groups at presentation; multidetector computed tomography (MDCT) has become the standard modality with high sensitivity and specificity. The American College of Radiology recommend the use of intravenous contrast-enhanced computed tomography for suspected cases but no explicit comment on the use of enteral contrast which create diversity in the literature for the appropriate MDCT protocols worldwide. The objective of this study is to compare the accuracy, sensitivity and specificity of variant MDCT protocols in diagnosing acute appendicitis.

Methodology: A retrospective cross-sectional study was conducted at Alnoor Specialist Hospital – Makkah between January 2016 and December 2020 including all patients who presented to the emergency department with clinical suspicion of acute appendicitis and performed MDCT scans with subsequent surgical intervention. A net of 385 MDCT scans were retrieved from hospital System (PACS). Data processing was made on exported coded excel sheet data and analyzed by SPSS 26.0 statistical software.

Results: 385 MDCT scans with different protocols were collected (NECT, ORAL only, IV only, ORAL and IV). Excluding ones without final diagnose 355 MDCT scans were analyzed. Radiologists'ability to detect acute appendicitis was higher in patients administered both oral and IV contrast (sensitivity =92.44%), IV only (89.61%), NECT (82.35%), and oral contrast (73.47%), respectively. Diagnostic accuracy was higher in patients administered both oral and IV contrast (accuracy = 89.23%).

Conclusion: The present study demonstrates that the diagnostic accuracy and sensitivity in diagnosing acute appendicitis utilizing IV contrast are comparable to both IV and oral contrast; therefore, oral contrast administration can be omitted in routine appendicitis protocol. A higher specificity was found with the use of oral contrast due to the luminal filling of the appendix. Yet, it can be reserved for contraindicated cases to IV iodinated contrast administration. CT scan showed a hundred percent sensitivity in diagnosing perforated appendicitis regardless of the used protocol.

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DOI: 10.53555/ecb/2022.11.11.201

Introduction:

Diagnosing acute appendicitis clinically is challenging due to variant age groups at presentation; variable clinical scenarios were around 20% presented with atypical clinical features and the possibility of associated different abdominal pathology (1–3). Furthermore, the number of removals of a normal appendix or so-called "negative appendectomy rates" was as high as 40 - 50%(4–6). However, this rate has decreased since the introduction of radiological imaging due to the ability to detect normal appendix or alternative medical conditions. While still high, the acceptable negative appendectomy rates are around 15 – 25% (7–10).

Ultrasonography (US) has been used as the initial imaging modality for establishing the diagnosis of acute appendicitis in children and women of reproductive age for potential gynecological entities with a sensitivity range from 44 – 95%(11,12). However, widely known limitations of the US include operator dependence, being affected by gaseous distension of the abdomen, and not reliable in detecting the normal or perforated appendix(12,13).

Therefore, multidetector computed tomography (MDCT) has become the standard modality with sensitivity and specificity ranging from 88 – 100% and 91 – 99%, respectively(12). The American College of Radiology (ACR) appropriateness criteria evidence-based guidelines recommend the use of intravenous (IV) contrast-enhanced computed tomography (CECT) for suspected cases of acute appendicitis but no explicit comment on the use of enteral contrast and refer it to the propensity of the institutions which create diversity in the literature for the appropriate MDCT protocols worldwide with different institutional experiences (14–16).

Unfortunately, there was no available local data to compare different MDCT scan protocols when acute appendicitis is suspected. Therefore, the present study aims to determine the sensitivity, specificity, and accuracy of MDCT in diagnosing acute appendicitis with variant-used protocols, as well as building a local institutional experience to protocol acute appendicitis cases.

Materials and Methods:

Study Population and Setting:

The investigation was approved by the Institutional Board Review (IRB) of the general directorate of health affairs in Makkah – Saudi Arabia. A retrospective cross-sectional study was conducted at Alnoor Specialist Hospital – Makkah between January 2016 and December 2020. The study included all the patients who presented to the emergency department with a clinical impression of acute appendicitis and performed preoperative MDCT scans with subsequent surgical intervention by either open or laparoscopic appendectomy. A total number of 385 MDCT scans were retrieved from the hospital Picture Archiving and Communication System (PACS).

Study Technique and Image Interpretation:

All patients were scanned using a 256-slice MDCT scanner (SIEMENS, SOMATOM Definition Flash). Image acquisition is made from lung bases to the greater trochanter of the femur. A slice thickness of 2 mm axial images with 3 mm multiplanar coronal and sagittal reformats were obtained. Different protocols were used, including non-enhanced CT (NECT) scans, Oral only, Intravenous (IV) only, or both oral and IV contrast agents. Per institutional protocol, a (2 ml/kg of iohexol 350 mg I/ml or iodixanol 320 mg I/mL, GE Healthcare) of IV contrast was administered by a power injector (Stellant CT Injection System, Medrad, Indianola, PA) at a rate of 3-4 mL/s with a time delay of 70 s after injection followed by a 30 mL bolus of chasing normal saline. For patients who received oral contrast, preparation of (30 mL of Gastrografin 37% Solution 12x120 Ml, Bracco Diagnostic) was diluted in 1 – 1.2 L of water and administered 2 hours before image acquisition.

Two Saudi board-certified radiologists were enrolled in this research. They reviewed all the MDCT scans and completed a pre-designed structural report containing the used protocol, demographic data, specific data regarding the appendix, and their final impression regarding each case. The examiners were blinded to the final diagnosis, intraoperative findings, and histopathology report. Finally, the data was exported to an excel sheet and Statistical Package for the Social Sciences (SPSS) for analysis.

The presence of acute appendicitis depends on the following CT findings: Dilated appendix (diameter > 6 mm), mural thickening, mucosal hyperenhancement, appendicolith, absence of intraluminal gas or contrast, peri-appendiceal fat stranding, and free fluid. Complicated appendicitis with inflammatory mass, perforation, or collection was also documented. The final impression was fallen into one of the following categories; acute non-complicated appendicitis, perforated appendicitis, appendicitis with collection, appendicitis with malignancy, equivocal appendicitis, stump appendicitis, or normal appendix. Final CT diagnoses were compared with operative and pathology reports.

Statistical Analysis:
All data processing was made on exported coded excel sheet data and analyzed by SPSS 26.0 statistical software package. Data were presented as frequencies or means ± standard deviation. The diagnostic sensitivity, specificity, positive predictive value (PPV), negative predictive value (NPV), and diagnostic accuracy were calculated from the four different protocols. A value of $p < 0.05$ was considered to indicate statistical significance.

Results:
385 MDCT scans of the abdomen and pelvis utilizing different protocols were collected (NECT, ORAL only, IV only, ORAL and IV). Final impressions of diagnoses that were not available were excluded from the final analysis. Therefore, 355 MDCT scans were analyzed: 89 (25.07%) in the NECT group, 54 (15.21%) in the oral group, 82 (23.01%) in the IV group, and 130 (36.62%) in the oral and IV contrast groups. A total of 232 (65.35%) male patients and 123 (34.65%) female patients data were analyzed in this study. No significant difference was observed in the gender and age mean differences with different protocols used (Table 1).
All MDCT scans of the abdomen and pelvis were assessed for acute appendicitis. True positives and negatives, false positives and negatives were determined by comparing the CT scan findings to the final histopathology reports. Of the 295 patients with positive CT findings for appendicitis, 285 were confirmed by correlating the radiological findings with histopathological findings. Among the 285 true positive results, 70 were NECT, 36 were oral, 69 were IV, and 110 were both oral and IV, respectively. There were 58 patients with a normal appendix. Other patients were diagnosed with perforated appendicitis, appendicitis with collection, and an appendix with malignancy. Radiologists' ability to detect acute appendicitis was higher in patients administered both oral and IV contrast (sensitivity =92.44%), following IV only (89.61%), NECT (82.35%), and oral contrast (73.47%), respectively (Table 2). Diagnostic accuracy was higher in patients administered both oral and IV contrast (89.23%).
The MDCT findings of patients who received oral contrast showed more true negative results (specificity =80%) than other protocols. In the final impression of radiologists correlating radiological and histopathological findings, the most frequently diagnosed conditions were acute non-complicated appendicitis (309 patients) and perforated appendicitis (12 cases). All 12 patients with perforated appendices were correctly diagnosed by CT scan. Hence, the sensitivity of diagnosing the perforated appendix was 100% in each protocol (**Error! Reference source not found.**). There was a total of 45 false-negative findings of MDCT. Fifteen were administered NECT, thirteen were oral, eight were IV contrast and nine were oral and IV administered patients (**Error! Reference source not found.**).

Discussion:
The value of MDCT in diagnosing acute appendicitis has been the subject of many studies worldwide. Various protocols have been used, including NECT, enteral (oral or rectal), IV or combination IV, and enteral contrast (17). Reducing the field of view using a focused CT scan at the right lower quadrant to decrease radiation dose has also been suggested (16).
The present study shows a higher ability to detect acute appendicitis in patients administered both oral and IV contrast with a sensitivity of 92.44%, followed by IV only (sensitivity of 89.61%); however, there was no significant difference (P-value = 0.43) which is consistent with the established literature that a CT scan utilizing oral contrast does not improve the diagnostic accuracy of acute appendicitis (7,17,18). A study published in 2016 concluded that the use of oral contrast in diagnosing acute appendicitis might be associated with a higher pulmonary complication rate, including pneumonia and acute respiratory distress syndrome as 93.75% of those who had complications received oral contrast compared to those who had IV contrast only ($P > 0.0001$). It also delays patients' transition from the emergency department to the operating room by an average of 4 hours (19).
In our study, the overall specificity values were low, ranging from 40 – 80%, which is expected as the inclusion criteria were all the patients who performed appendectomy (the true negative cases were only 58 from a total of 355). The specificity in the literature ranged from 97 to 100% as they included all the patients who presented to the emergency department with acute non-traumatic abdominal pain and were suspected clinically to have acute appendicitis. The standard reference for the final diagnosis was either surgical and histopathological correlation or specific follow-up criteria to ensure the resolution of symptoms (14,20,21). The highest specificity in our study was 80% in the orally administered contrast agent. The reason mentioned in the literature is that the opacification of the appendix with oral contrast helps exclude acute appendicitis (5,17,22). Keyzer et al. found that the visualization of the normal appendix in the oral-contrast group was 81 – 96%

compared to 74 – 85% in the no-oral contrast group (21).

Perforated appendicitis is considered when there is discontinuity of the appendiceal wall, extraluminal air or appendicolith, contrast leak, or abscess formation. Our study demonstrates 100% sensitivity in detecting perforated appendicitis with no statistical difference between different used protocols. A 94.9% sensitivity was documented by Horrow et al. in diagnosing perforated appendicitis, considering a focal defect in the enhancing appendiceal wall is the most sensitive indicator of perforation (23).

This study has several limitations, including its retrospective nature. The pre-knowledge of participated radiologists about the research aims in diagnosing acute appendicitis might guide them toward the diagnosis rather than if it was a general indication as acute abdomen. Lastly, the inclusion criteria limit the number of the normal appendix as we only included all the patients who did appendectomy following high clinical suspicion, laboratory and radiological investigations and ruled out a possible differential diagnosis, resulting in only a small number of true negative cases which affect the specificity in our study when compared to the literature. However, the chosen criteria allowed us to actually compare the sensitivity of each protocol to a final diagnosis confirmed operatively and histopathologically.

Conclusion:

The present study demonstrates that the diagnostic accuracy and sensitivity in diagnosing acute appendicitis utilizing IV contrast are comparable to both IV and oral contrast; therefore, oral contrast administration can be omitted in routine appendicitis protocol. A higher specificity was found with the use of oral contrast due to the luminal filling of the appendix. Yet, it can be reserved for contraindicated cases to IV iodinated contrast administration. CT scan showed a hundred percent sensitivity in diagnosing perforated appendicitis regardless of the used protocol.

Footnotes:

Funding

The authors have not declared a specific grant for this research from any funding agency in the public, commercial or not-for-profit sectors.

Declaration of competing Interests

None of the authors have any conflict of interest to declare.

Institutional Review Board Statement

This clinical study has been approved by the Institutional Ethics Committee at Makkah healthcare cluster on 24.06.2021 IRB Number: H-02-K-076-0621-516

Table 1: *Characterization of patients across the four protocols:*

	NECT (89)	ORAL ONLY (54)	IV ONLY (82)	ORAL+IV(130)
Gender				
Male	55 (61.8%)	35 (64.8%)	57 (69.5%)	85 (65.4%)
Female	34 (38.2%)	19 (35.2%)	25 (30.5%)	45 (34.6%)
Age				
Mean± SD	36.42 ± 13.98	38.70 ± 15.84	37.87 ± 13.23	38.11 ± 14.76

Table 2: Diagnostic performance of the utilized protocol (NECT, oral only, IV only, and both oral and IV contrast):

	NECT (95% CI)	**ORAL ONLY (95% CI)**	**IV ONLY (95% CI)**	**ORAL+IV (95% CI)**
Sensitivity	82.35% (72.57 -89.77)	73.47% (58.92 - 85.05)	89.61% (80.55 - 95.41)	92.44% (86.13 - 96.48)
Specificity	75% (19.41 - 99.37)	80% (28.36 - 99.49)	40% (5.27 - 85.34)	54.5% (23.38 - 83.25)
Accuracy	82.02% (72.45 - 89.36)	74.07% (60.35 - 85.04)	86.59% (77.26- 93.11)	89.23% (82.59- 93.99)
PPV	98.59% (92.75 - 99.74)	97.30% (86.09 - 99.52)	95.83% (91.80 - 97.93)	95.65% (91.99 - 97.68)
NPV	16.67% (72.45 - 89.36)	23.53% (13.96 - 36.84)	20.00% (6.63 - 46.80)	40.00% (22.56 - 60.41)

PPV; Positive Predictive Value; NPV: Negative Predictive Value; CI; Confidence Interval.

Table 3: True positive rates of diagnosing acute non-complicated appendicitis and perforated appendicitis:

	NECT (95% CI)	**ORAL ONLY (95% CI)**	**IV ONLY (95% CI)**	**ORAL+IV (95% CI)**
Acute non-complicated appendicitis	82.93% (73.02 – 90.34)	75% (59.66 – 86.81%)	89.04% (79.54 – 95.15)	92.73 (86.17 – 96.81)
Perforated appendicitis	100%	100%	100%	100%

Table 4: False negative diagnoses in different protocols:

	No. of patients
NECT	
Acute non-complicated appendix	14
Acute appendix with malignancy	1
ORAL only	
Acute non-complicated appendix	11
Acute appendix with malignancy	2
IV only	
Acute non-complicated appendix	8
ORAL +IV	
Acute non-complicated appendix	8
Acute appendix with malignancy	1

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