

Revised version | 13 September 2026

Comparison of diagnostic performance of CT with rectal contrast vs. CT with rectal and intravenous contrast for the diagnosis of acute appendicitis

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Abstract

Aim: To describe the diagnostic performance of CT with rectal contrast (CT-RC) and CT with rectal and intravenous contrast (CT-IVRC) in patients with suspected acute appendicitis.

Materials and methods: The reported single-centre retrospective cohort comprised 135 patients examined in 2020 with both CT techniques and assessed by two radiologists. The reference diagnosis was based on surgery/histopathology or clinical follow-up. For this revision, diagnostic measures and 95% Wilson confidence intervals were recalculated from the reported aggregate counts. Indeterminate results were reported separately; determinate-case estimates and alternative classification scenarios were examined.

Results: The reported cohort contained 56 patients with appendicitis and 79 without appendicitis. For observer 1, accuracy was 89.6% (95% CI, 83.3-93.7) for CT-RC and 87.4% (80.8-92.0) for CT-IVRC. Observer 2 had two indeterminate results per technique, both in the non-appendicitis group. Among 133 determinate results, accuracy was 86.5% (79.6-91.3) for CT-RC and 89.5% (83.1-93.6) for CT-IVRC. Alternative classifications of the indeterminate results changed these estimates.

Conclusions: These descriptive estimates depend on the accuracy of the reported counts, which could not be independently verified against patient-level data. The available aggregate information does not establish equivalence between the techniques or support a specific recommendation for patients with contraindications to intravenous contrast.

Keywords: acute appendicitis; computed tomography; rectal contrast; intravenous contrast; diagnostic accuracy

Descriptive recalculation of reported aggregate data. Version scope and declarations appear on [page 30](#).

Revised version | 13 September 2026

Introduction

Imaging contributes to the evaluation of suspected acute appendicitis and to the identification of alternative causes of abdominal pain. Diagnostic pathways must be considered alongside clinical assessment and treatment decisions. The 2020 WSES guidelines address these decisions [1], while trials of antibiotic treatment illustrate the importance of defining the diagnosis and patient population before comparing management strategies [2, 3].

Earlier publications examined adult ultrasonography, CT protocols and surgical outcomes, an ultrasound/MRI pathway in children, and MRI during pregnancy [4, 5, 6, 7, 8]. Their populations and designs differ.

The choice of CT protocol involves both image interpretation and contrast administration. Dillman et al. investigated acute allergic-like reactions to intravenous iodinated contrast in children [9]; this is evidence about contrast reactions, not about the relative diagnostic yield of appendicitis protocols. Kepner et al. compared intravenous contrast alone with intravenous plus oral contrast in adults, and Mun et al. evaluated CT using intravenous contrast without oral or rectal contrast [10, 11].

Rectal-contrast CT and unenhanced CT have also been investigated [12, 13]. Studies of imaging utilisation and hospital charges address an additional outcome that is distinct from diagnostic accuracy [14]. Other investigations examined rectal contrast against alternative CT protocols or clinical management, including studies by Hershko, Walker, Kharbanda, Naffaa and Mittal [15, 16, 17, 18, 19]. These studies provide context but cannot determine the results of the present cohort.

The original study compared CT-RC with CT-IVRC in the same patients. This revised presentation describes the reported diagnostic counts and a reproducible aggregate-data recalculation. It does not reconstruct unavailable patient-level observations or the original comparative statistical output.

Materials and methods: study cohort

The submitted manuscript describes a single-centre retrospective study of patients presenting to the emergency department with non-traumatic right lower quadrant or lower abdominal pain and clinical suspicion of acute appendicitis between January and December 2020. The electronic database was searched for patients who underwent both CT-RC and a subsequent CT-IVRC acquisition. Patients with only one of these acquisitions were excluded. The number screened and excluded, and whether enrolment was consecutive, were not reported.

The cohort comprised 135 patients. The source assigned a final diagnosis of appendicitis to 56 and a non-appendicitis diagnosis to 79. The stated reference was surgery/histopathology or conservative management with follow-up for more than two months. The counts verified by each reference pathway, follow-up completeness and the possible influence of CT on the reference diagnosis were not available for this revision.

Table 1. Source-reported baseline summaries

Variable	Appendicitis (n=56)	Non-appendicitis (n=79)
Age	33 (19-91)	30 (19-61)
BMI	27.25 ± 6.1	28.81 ± 7.78
CRP	24 (range unresolved)*	10 (10-235.5)
WBC	9.65 (4.33-18.77)	8.49 (3.59-19.22)
Sex (Female / Male)	20 / 36	46 / 33
Diameter, mm: OB1 (CT-RC)	10 (3.5-20)	5.2 (2.4-29)
Diameter, mm: OB2 (CT-RC)	10 (4.8-20)	5 (2-25)
Diameter, mm: OB1 (CT-IVRC)	10 (3-21)	4.5 (1.8-28.5)
Diameter, mm: OB2 (CT-IVRC)	10 (range unresolved)*	5 (2-28)

Values are source-reported median (range), except BMI (mean ± SD) and sex (counts). CRP and WBC units were not specified. *The source gives a CRP median of 24 with range 50-463.4 and a CT-IVRC OB2 diameter median of 10 with range 4-8. These ranges are internally inconsistent and cannot be reconstructed. Medians are retained as reported, not independently verified. OB1/OB2: observers 1/2.

Revised version | 13 September 2026

CT acquisition

The source describes a 64-slice multidetector CT scanner. CT-RC was acquired first. Rectal contrast consisted of 20-30 mL of iodinated contrast mixed with 1-1.5 L of normal saline, administered through a rectal tube with the patient in the left lateral position. Patients were then turned supine and to the right lateral position to facilitate passage towards the caecum. Scanning was performed after approximately 20 minutes, with the patient supine and a single breath-hold.

Reported acquisition parameters were slice thickness 1-1.5 mm, tube voltage 100-120 kVp, tube current-time product 90-130 mAs and pitch 1.5. Automatic exposure control was used. Images were reconstructed at 1-mm thickness with a 0.7-mm increment. A second acquisition was performed in the same position after intravenous contrast administration in the portal venous phase. The scanner model, contrast agent and concentration, intravenous dose and exact delay were not specified in the available manuscript; no replacement protocol has been assumed.

Image interpretation

A third radiologist anonymised the examinations. Two radiologists, described as a consultant and a resident with 15 and four years of experience, independently assessed the images and were blinded to clinical and outcome information. The order in which the two image sets were presented and any washout interval were not documented. Independence between readings of the two techniques therefore cannot be established from the report.

The reported imaging assessment included appendiceal visibility and diameter, luminal air or contrast, appendicolith and periappendiceal inflammatory findings. The source described a diameter above 6 mm with surrounding inflammation and a non-opacified lumen as diagnostic criteria; how these criteria were combined when findings were discordant was not specified. The supplied cases include partial luminal opacification despite appendicitis, as discussed below.

Descriptive statistical reanalysis

The original manuscript named SPSS version 21 and described Fisher exact tests, t tests or Mann-Whitney tests and Cohen kappa. The present recalculation was performed from the submitted aggregate tables because a case-level dataset and original statistical output were not available to the editorial team. It is a new descriptive recalculation, not a reproduction of the original software analysis. Reporting of counts, denominators and indeterminate results follows the relevant principles in STARD [20].

Sensitivity, specificity, positive and negative predictive values and accuracy were calculated using the reported diagnostic cross-tabulations. Accuracy means the proportion correctly classified, not the mean of sensitivity and specificity. Two-sided 95% Wilson score intervals were calculated for individual proportions without continuity correction. For observer 2, determinate-case estimates exclude the two indeterminate results per technique; scenarios assigning both to positive or negative categories are shown separately. These are explicitly post hoc descriptive scenarios, not a recovered original analysis plan.

No AUC, paired comparison p value, equivalence test or inter-reader agreement estimate was reconstructed. Only observer 1's binary kappa against the reported reference diagnosis was recalculated. Descriptive feature percentages use the full reference-group denominators, including N/A entries. Two inconsistent source ranges remain unresolved in [Table 1](#); no substitute values were imputed.

Limitations of the source data

The retrospective, single-centre design and the reported sample size limit generalisability. Selection and reference-standard pathways are incompletely described; follow-up completeness and independence of reference assessment cannot be verified. Reading-order effects cannot be excluded. The absence of linked case-level data prevents verification of counts, paired comparisons and reader agreement. Source inconsistencies in baseline ranges also remain unresolved.

Revised version | 13 September 2026

Results

The reported cohort included 69 male and 66 female patients; mean age was 32.26 years (SD 11.73). The appendicitis group contained 36 male and 20 female patients; the non-appendicitis group contained 33 male and 46 female patients. [Table 1](#) presents the available baseline summaries as source-reported values, with unresolved ranges identified explicitly.

[Tables 2 and 3](#) retain the reported feature counts for CT-RC and CT-IVRC and recalculate the associated percentages. Each feature totals 56 appendicitis and 79 non-appendicitis observations when N/A entries are included. Statistical associations and feature-level reader agreement are not newly inferred from these summaries. [Figures 1, 2, 3, 4 and 5](#) reproduce the submitted illustrative images with their clinical descriptions.

The diagnostic counts are displayed in [Table 4](#). Observer 1 had 49 true-positive and 72 true-negative CT-RC classifications, compared with 47 and 71 on CT-IVRC. Corresponding sensitivities were 87.50% and 83.93%, specificities 91.14% and 89.87%, and accuracies 89.63% and 87.41%. Recalculated binary kappa against the reported reference diagnosis was 0.786 for CT-RC and 0.740 for CT-IVRC.

Observer 2 had two indeterminate results per technique, all in the non-appendicitis group; their correspondence across techniques was unknown. Among 133 determinate results, sensitivity was 82.14% for CT-RC and 89.29% for CT-IVRC; specificity was 89.61% for both, and accuracy was 86.47% and 89.47%, respectively ([Table 5](#)).

If both indeterminate results were classified as positive, observer 2's accuracies would be 85.19% for CT-RC and 88.15% for CT-IVRC. If classified as negative, they would be 86.67% and 89.63%. [Table 5](#) provides the determinate-case estimates and the scenario results. These scenarios do not establish how the original analysis treated the indeterminate observations.

Discussion

The revised estimates describe performance within the reported cohort and show why the underlying counts and denominators matter. The direction of the descriptive difference in accuracy varied by observer. Marginal totals do not identify which patients were classified differently by the two techniques; they therefore do not support a reconstructed paired comparison. Confidence intervals for individual proportions are not confidence intervals for a paired difference. Neither overlapping intervals nor a non-significant difference would establish equivalence [\[21\]](#).

Rao et al. reported 98% sensitivity and accuracy in 100 patients examined with colon-administered contrast; Walker et al. reported 94% sensitivity, 100% specificity and 96% accuracy [\[12, 16\]](#). These historical, study-specific results cannot validate the present counts or establish interchangeability of the techniques.

All included patients received intravenous contrast as part of the second acquisition. Consequently, this cohort did not directly test a population unable to receive intravenous contrast. It also did not provide comparative measurements of examination time, costs, adverse reactions or patient discomfort. Claims about these outcomes from earlier investigations must remain attributed to those studies [\[9, 10, 14, 19\]](#).

Excluding indeterminate results may change the population represented by an accuracy estimate. The determinate-case analysis is therefore accompanied by explicit counts and classification scenarios. The confidence intervals quantify binomial sampling uncertainty conditional on the supplied counts; they do not account for possible errors in those counts or bias in the underlying study.

Conclusion

The reported tables permit a descriptive recalculation of diagnostic performance, conditional on the accuracy of their absolute counts. The available evidence does not establish equivalence between CT-RC and CT-IVRC and does not support a specific recommendation for patients with contraindications to intravenous contrast. Interpretation requires the stated limitations of aggregate-data reanalysis and indeterminate-result handling.

Revised version | 13 September 2026

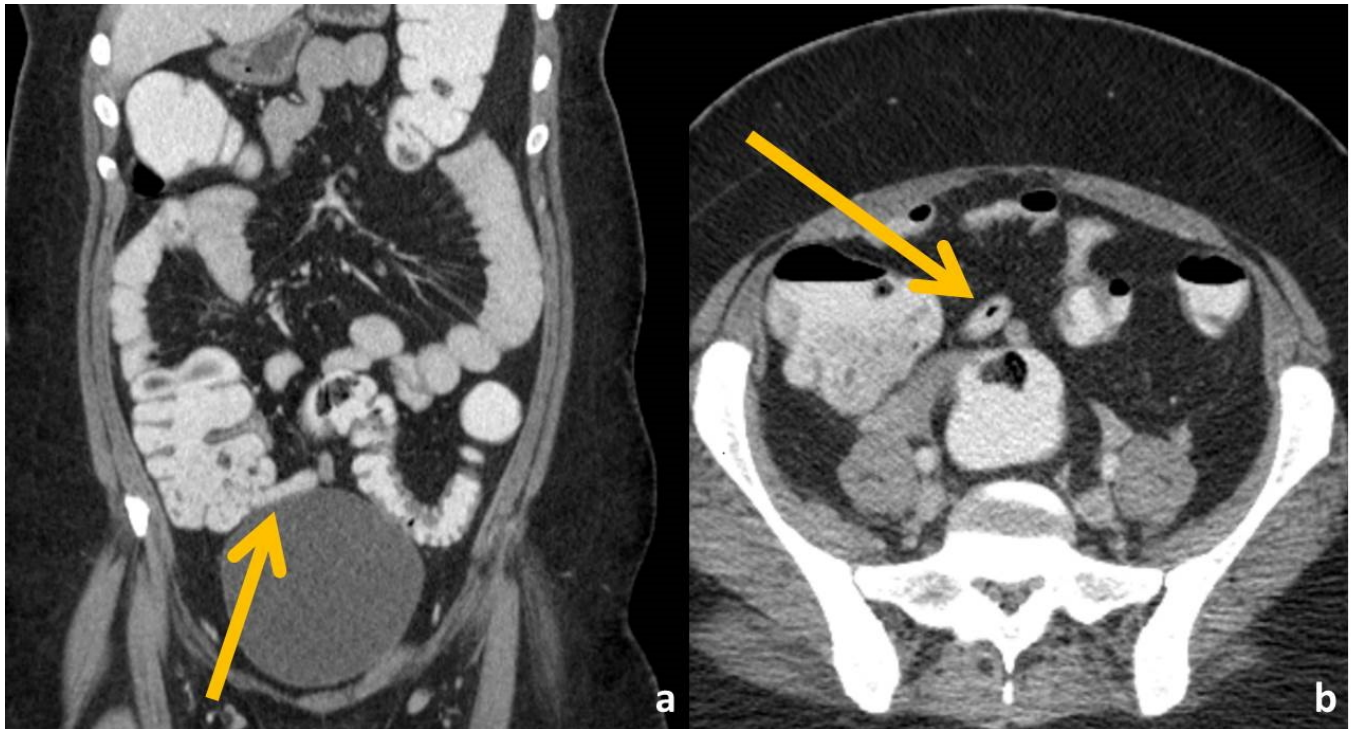
Figure 1

Figure 1. A 29-year-old female patient presented to the emergency service with lower abdominal pain. Ultrasonography was performed, but inconclusive and limited due to increased subcutaneous fat (obesity). The patient underwent computed tomography abdomen and pelvis with intravenous and rectal contrast which showed increased appendix diameter (10 mm) with intraluminal contrast filling (yellow arrows) without adjacent peri appendiceal fat stranding, wall thickening or free fluid. A right adnexal lesion was detected (not shown here). The diagnosis of acute appendicitis was excluded.

Revised version | 13 September 2026

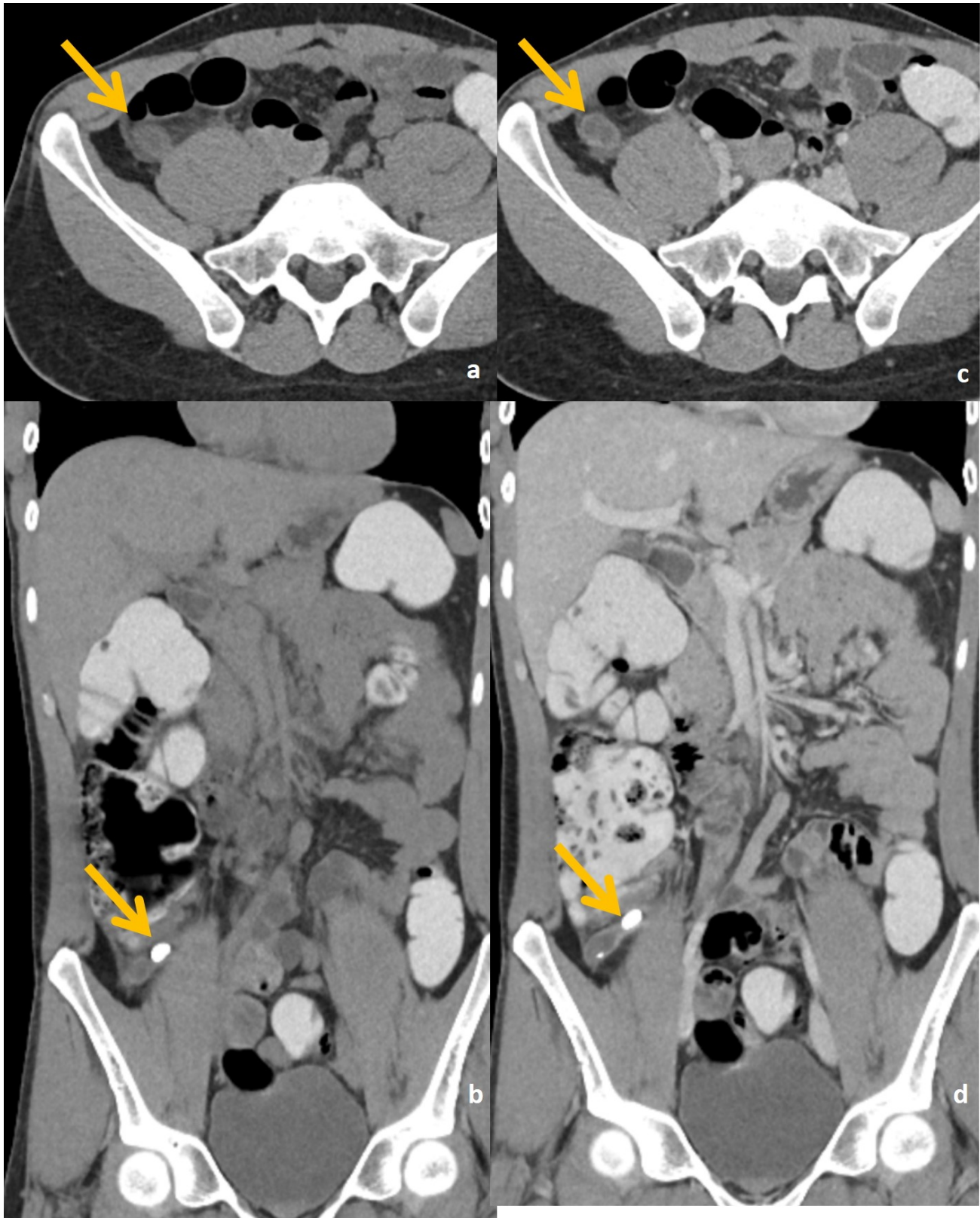
Figure 2

Figure 2. A 28-year-old male patient with a proven diagnosis of acute appendicitis. Axial computed tomography image with rectal contrast shows a distended appendix with hazy periappendiceal fat stranding (arrow) (a). There is no intraluminal rectal contrast with barely demonstrated appendiceal wall thickening. On coronal image (b) obstructive appendicolith is detected (arrow). After administration of intravenous contrast, axial (c) and coronal (d) computed tomography images; appendix wall thickening is seen with significant periappendiceal fat stranding (arrow).

Revised version | 13 September 2026

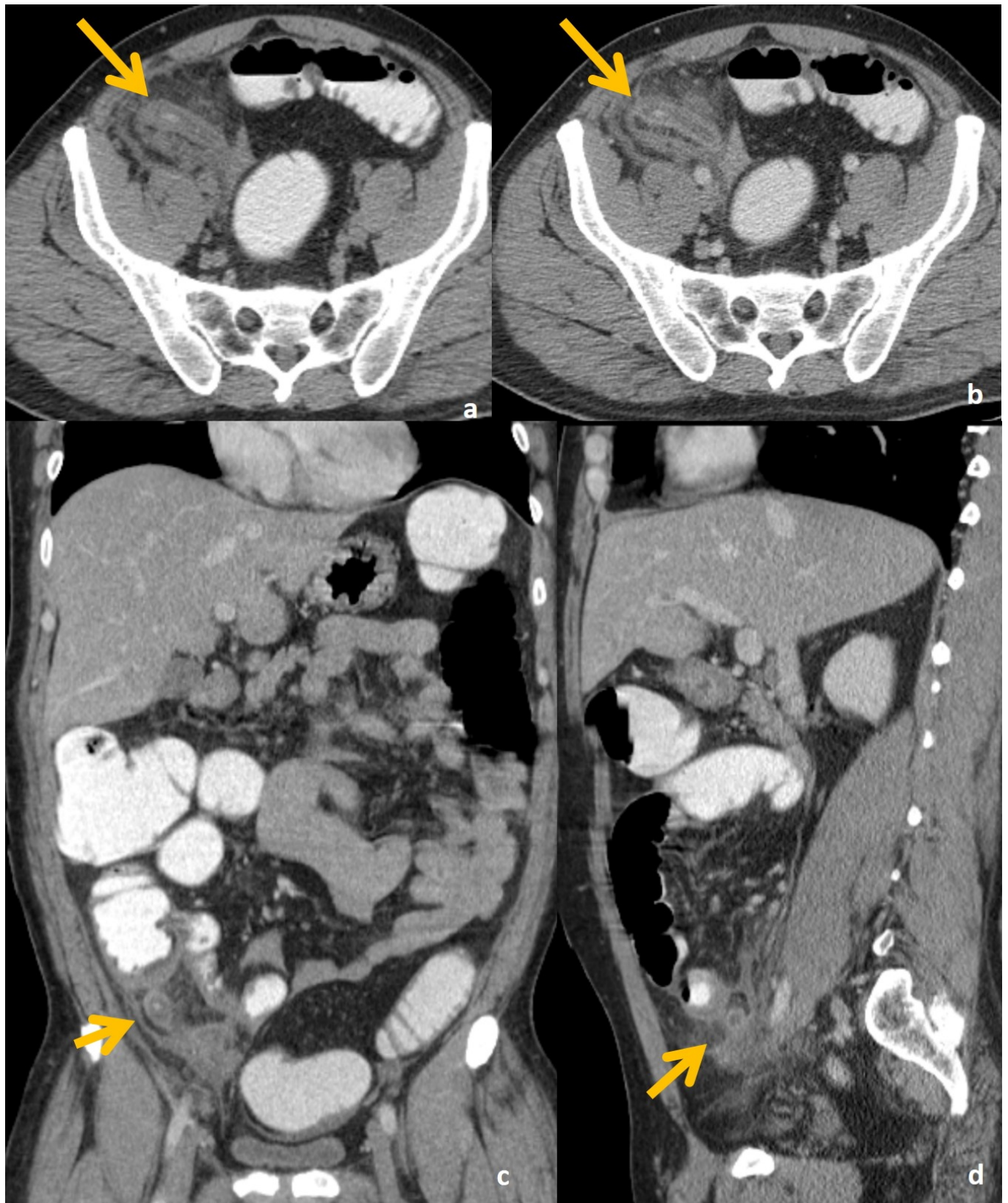
Figure 3

Figure 3. A 52-year-old male patient with acute appendicitis. Axial computed tomography images with rectal (a) contrast only show significant fat stranding around the distended appendix with significant wall thickening and intraluminal obstructing appendicolith (arrow). After intravenous contrast administration same findings are seen (arrows on b-d).

Revised version | 13 September 2026

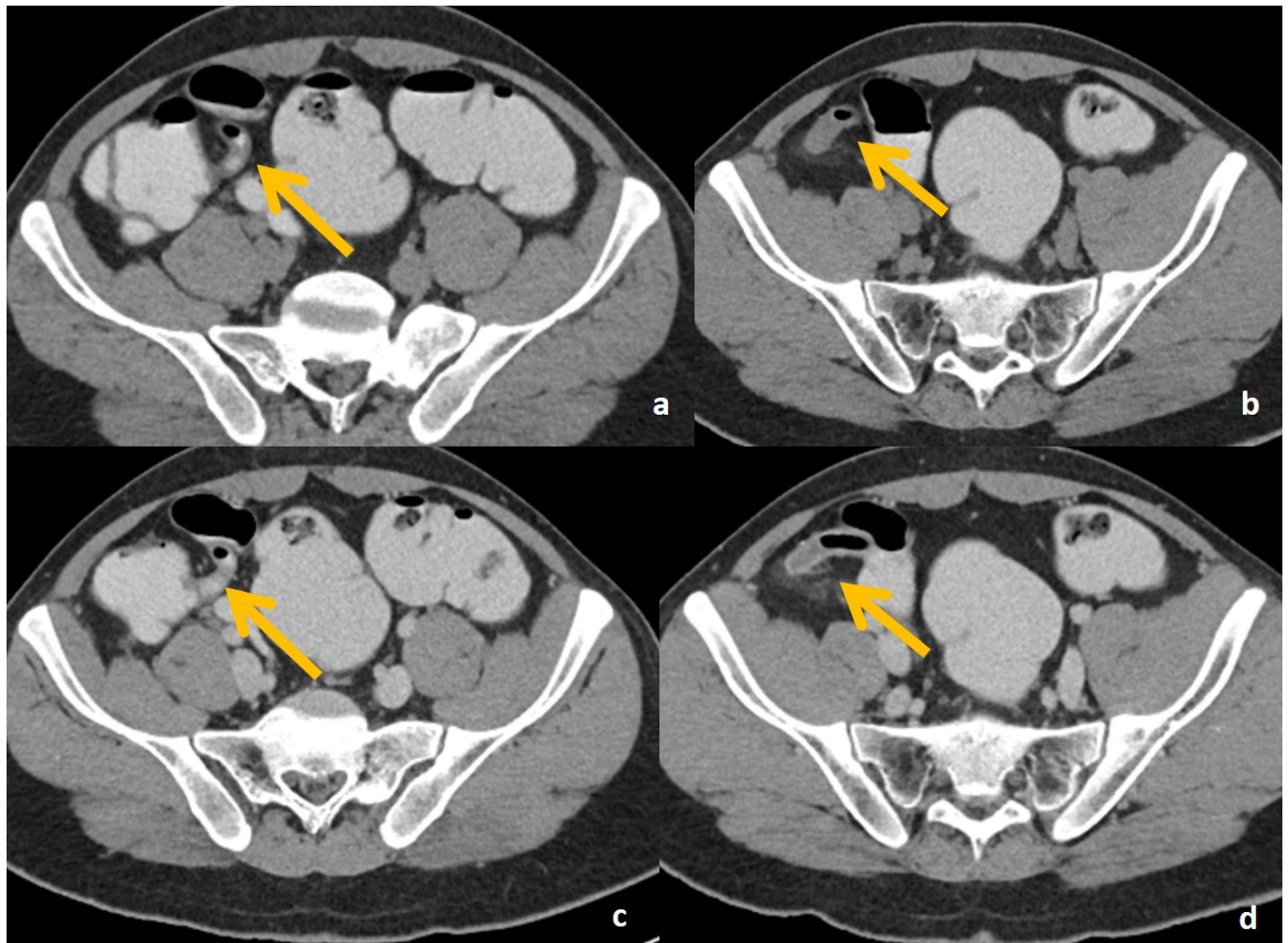
Figure 4

Figure 4. A 22-year-old male presented with right iliac fossa pain, fever, nausea, and vomiting. Abdomen examination showed right iliac fossa tenderness with voluntary guarding. Axial computed tomography images with rectal (a) contrast only show rectal contrast in the proximal and mid part of the appendix (a). However, there is no contrast in the distal part (b) with no demonstrable wall thickening, but faint periappendiceal fat stranding. After intravenous contrast administration proximal and mid part of the appendix show no abnormal wall thickening and enhancement (c). However significant enhancing wall thickening is noted with periappendiceal fat stranding (d). The patient was diagnosed with distal tip acute appendicitis on computed tomography images and confirmed histopathologically.

Interpretation of partial luminal opacification

Partial luminal opacification must not be treated as an unconditional exclusion of appendicitis. The submitted descriptions of Figures 4 and 5 report contrast in proximal appendiceal segments despite histologically confirmed appendicitis affecting more distal portions. These illustrative cases are not a separate diagnostic accuracy study.

Revised version | 13 September 2026

Figure 5

Figure 5. A 20-year-old male came in with a history of central abdominal pain which radiated to the right iliac fossa with vomiting. He had tenderness and positive rebound at RIF, with a reported positive Rovsing sign. Axial rectal contrast computed tomography images (a and b) show air and rectal contrast in the proximal part of the appendix and abnormal wall thickening posterior to the cecum which cannot be differentiated from a fluid collection or inflammatory changes. After intravenous contrast administration mid and distal part of the appendix show enhancing wall thickening with surrounding fat stranding without intraluminal contrast on corresponding axial computed tomography images (c and d). The patient was diagnosed with acute appendicitis histopathologically.

Revised version | 13 September 2026

Table 2. Reported CT-RC imaging findings

Feature / category	OB1: AA (n=56)	OB1: non-AA (n=79)	OB2: AA (n=56)	OB2: non-AA (n=79)
Wall thickening				
Present	43 (76.8)	9 (11.4)	43 (76.8)	7 (8.9)
Absent	13 (23.2)	70 (88.6)	13 (23.2)	70 (88.6)
N/A	0 (0.0)	0 (0.0)	0 (0.0)	2 (2.5)
Intraluminal contrast				
Present	5 (8.9)	52 (65.8)	9 (16.1)	63 (79.7)
Absent	51 (91.1)	27 (34.2)	47 (83.9)	14 (17.7)
N/A	0 (0.0)	0 (0.0)	0 (0.0)	2 (2.5)
Intraluminal air				
Present	8 (14.3)	47 (59.5)	9 (16.1)	59 (74.7)
Absent	48 (85.7)	32 (40.5)	47 (83.9)	18 (22.8)
N/A	0 (0.0)	0 (0.0)	0 (0.0)	2 (2.5)
Periappendiceal LN				
Present	44 (78.6)	15 (19.0)	45 (80.4)	31 (39.2)
Absent	12 (21.4)	64 (81.0)	11 (19.6)	48 (60.8)
Appendicolith				
Present	16 (28.6)	1 (1.3)	13 (23.2)	1 (1.3)
Absent	40 (71.4)	78 (98.7)	43 (76.8)	78 (98.7)
Periappendiceal fat stranding				
Present	49 (87.5)	12 (15.2)	44 (78.6)	11 (13.9)
Absent	7 (12.5)	67 (84.8)	12 (21.4)	67 (84.8)
N/A	0 (0.0)	0 (0.0)	0 (0.0)	1 (1.3)
Periappendiceal fluid				
Present	9 (16.1)	2 (2.5)	23 (41.1)	2 (2.5)
Absent	47 (83.9)	77 (97.5)	33 (58.9)	76 (96.2)
N/A	0 (0.0)	0 (0.0)	0 (0.0)	1 (1.3)
Wall interruption				
Present	10 (17.9)	3 (3.8)	7 (12.5)	1 (1.3)
Absent	46 (82.1)	76 (96.2)	49 (87.5)	76 (96.2)
N/A	0 (0.0)	0 (0.0)	0 (0.0)	2 (2.5)
Pericecal inflammation				
Present	28 (50.0)	11 (13.9)	21 (37.5)	11 (13.9)
Absent	28 (50.0)	68 (86.1)	35 (62.5)	68 (86.1)
Pericecal/appendiceal collection				
Present	8 (14.3)	9 (11.4)	5 (8.9)	5 (6.3)
Absent	48 (85.7)	70 (88.6)	51 (91.1)	74 (93.7)

Entries are count (percentage). Percentages were recalculated using all 56 appendicitis (AA) and 79 non-appendicitis patients; N/A entries remain in these denominators. A blank or dash in a source N/A cell is displayed as zero only where present and absent counts already exhaust the group. All-zero N/A rows are omitted. Absolute counts are retained from the submitted table and were not validated against patient records. OB1/OB2: observers 1/2. N/A: source category labelled not applicable. Diagnostic classifications are shown separately in [Table 4](#).

This descriptive presentation does not retain the original feature-level inferential or reader-agreement columns, which are not part of the revised claims.

Revised version | 13 September 2026

Table 3. Reported CT-IVRC imaging findings

Feature / category	OB1: AA (n=56)	OB1: non-AA (n=79)	OB2: AA (n=56)	OB2: non-AA (n=79)
Wall thickening				
Present	48 (85.7)	15 (19.0)	48 (85.7)	6 (7.6)
Absent	8 (14.3)	64 (81.0)	8 (14.3)	71 (89.9)
N/A	0 (0.0)	0 (0.0)	0 (0.0)	2 (2.5)
Wall enhancement				
Present	47 (83.9)	14 (17.7)	50 (89.3)	10 (12.7)
Absent	9 (16.1)	65 (82.3)	6 (10.7)	67 (84.8)
N/A	0 (0.0)	0 (0.0)	0 (0.0)	2 (2.5)
Intraluminal contrast				
Present	7 (12.5)	60 (75.9)	8 (14.3)	64 (81.0)
Absent	49 (87.5)	19 (24.1)	48 (85.7)	13 (16.5)
N/A	0 (0.0)	0 (0.0)	0 (0.0)	2 (2.5)
Intraluminal air				
Present	4 (7.1)	50 (63.3)	8 (14.3)	57 (72.2)
Absent	52 (92.9)	29 (36.7)	48 (85.7)	20 (25.3)
N/A	0 (0.0)	0 (0.0)	0 (0.0)	2 (2.5)
Periappendiceal LN				
Present	48 (85.7)	15 (19.0)	47 (83.9)	35 (44.3)
Absent	8 (14.3)	64 (81.0)	9 (16.1)	44 (55.7)
Appendicolith				
Present	18 (32.1)	2 (2.5)	13 (23.2)	1 (1.3)
Absent	38 (67.9)	77 (97.5)	43 (76.8)	78 (98.7)
Periappendiceal fat stranding				
Present	46 (82.1)	13 (16.5)	44 (78.6)	9 (11.4)
Absent	10 (17.9)	66 (83.5)	12 (21.4)	69 (87.3)
N/A	0 (0.0)	0 (0.0)	0 (0.0)	1 (1.3)
Periappendiceal fluid				
Present	18 (32.1)	3 (3.8)	23 (41.1)	4 (5.1)
Absent	38 (67.9)	76 (96.2)	33 (58.9)	75 (94.9)
Wall interruption				
Present	14 (25.0)	2 (2.5)	7 (12.5)	1 (1.3)
Absent	42 (75.0)	77 (97.5)	49 (87.5)	76 (96.2)
N/A	0 (0.0)	0 (0.0)	0 (0.0)	2 (2.5)
Pericecal inflammation				
Present	25 (44.6)	11 (13.9)	13 (23.2)	10 (12.7)
Absent	31 (55.4)	68 (86.1)	43 (76.8)	69 (87.3)
Pericecal/appendiceal collection				
Present	8 (14.3)	7 (8.9)	4 (7.1)	4 (5.1)
Absent	48 (85.7)	72 (91.1)	52 (92.9)	75 (94.9)

Entries are count (percentage). Percentages were recalculated using all 56 appendicitis (AA) and 79 non-appendicitis patients; N/A entries remain in these denominators. A blank or dash in a source N/A cell is displayed as zero only where present and absent counts already exhaust the group. All-zero N/A rows are omitted. Absolute counts are retained from the submitted table and were not validated against patient records. OB1/OB2: observers 1/2. N/A: source category labelled not applicable. Diagnostic classifications are shown separately in [Table 4](#).

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Revised version | 13 September 2026

Table 4. Reported diagnostic classifications

Technique / reader	TP	FN	FP	TN	Indeterminate*	Total
CT-RC / OB1	49	7	7	72	0	135
CT-RC / OB2	46	10	8	69	2	135
CT-IVRC / OB1	47	9	8	71	0	135
CT-IVRC / OB2	50	6	8	69	2	135

TP/FN: true positive/false negative among 56 appendicitis patients. FP/TN: false positive/true negative among 79 non-appendicitis patients. *All indeterminate results are in the non-appendicitis group. Their patient-level correspondence between techniques is unknown.

Table 5. Recalculated diagnostic performance

Measure	CT-RC / OB1	CT-RC / OB2*	CT-IVRC / OB1	CT-IVRC / OB2*
Determinate n	135	133	135	133
Sensitivity	87.50 (76.37-93.81)	82.14 (70.16-90.00)	83.93 (72.19-91.31)	89.29 (78.53-95.00)
Specificity	91.14 (82.82-95.64)	89.61 (80.82-94.64)	89.87 (81.27-94.78)	89.61 (80.82-94.64)
PPV	87.50 (76.37-93.81)	85.19 (73.40-92.30)	85.45 (73.84-92.44)	86.21 (75.07-92.84)
NPV	91.14 (82.82-95.64)	87.34 (78.24-92.98)	88.75 (79.98-93.97)	92.00 (83.63-96.28)
Accuracy	89.63 (83.34-93.72)	86.47 (79.62-91.26)	87.41 (80.76-91.99)	89.47 (83.11-93.63)

Values are percentages (95% Wilson confidence intervals). *Observer 2: determinate-case estimates, excluding two indeterminate non-appendicitis results per technique; specificity uses 77 non-appendicitis patients. These estimates are conditional on the reported counts and are not a reconstructed original primary analysis. PPV/NPV: positive/negative predictive values.

Table 5, continued: observer 2 classification scenarios

Technique / scenario	n	Sensitivity	Specificity	Accuracy
CT-RC / Determinate only	133	82.14%	89.61%	86.47%
CT-RC / Unclear → positive	135	82.14%	87.34%	85.19%
CT-RC / Unclear → negative	135	82.14%	89.87%	86.67%
CT-IVRC / Determinate only	133	89.29%	89.61%	89.47%
CT-IVRC / Unclear → positive	135	89.29%	87.34%	88.15%
CT-IVRC / Unclear → negative	135	89.29%	89.87%	89.63%

No scenario is evidence of the rule used in the original analysis. Confidence intervals for individual estimates do not establish equivalence or a paired difference. The binary kappa against the reported reference for OB1 is 0.786 (CT-RC) and 0.740 (CT-IVRC); no reader-to-reader kappa is newly claimed.

Revised version | 13 September 2026

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Revised version | 13 September 2026

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Declarations and version scope

Ethics: King Hamad University Hospital IRB approval 22-484, dated 9 February 2022, was available. The original manuscript states that patient consent was waived; supporting waiver documentation was not available for this revision. Publication consent requires separate clarification.

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Data availability: This revised analysis uses aggregate counts and summary statistics from the submitted manuscript and tables. Patient-level data and the original statistical output were not available to the editorial team for independent verification. No claim is made that individual datasets have been archived or can be supplied on request.

Version scope: This revised version replaces inconsistent diagnostic performance estimates with a documented recalculation from the reported counts. Unverifiable AUC, paired-comparison and reader-agreement claims have been removed; two baseline ranges remain unresolved. The supplied figure legends have been restored and the duplicate reference consolidated. Original study records have not been independently validated.