European Journal of Radiology Open 6 (2019) 330–335

Contents lists available at ScienceDirect

European Journal of Radiology Open

journal homepage: www.elsevier.com/locate/ejro

Reliability of standardized reporting system of acute appendicitis in adults at low-dose 320-rows CT

Shravan Kumar Mahankali[a], Ahmed Abdel Khalek Abdel Razek[b,*], Shefeek Abubacker Ahamed[a]

[a] Diagnostic Radiology Department. Ahmadi Hospital (KOC) Al-Ahmadi, Kuwait
[b] Diagnostic radiology department, Mansoura faculty of medicine, Mansoura University, Mansoura, Egypt

ARTICLE INFO

Keywords:
Computed tomography
Appendicitis

ABSTRACT

Aim: To assess the reliability of a standardized reporting system of acute appendicitis at low-dose 320-rows CT.
Subjects and Methods: Retrospective analysis CT of 78 patients with pathologically proven acute appendicitis. The study was performed at a low-dose 320-rows CT. The image analysis was performed by 2 radiologists according to a standardized reporting system of acute appendicitis.
Results: There was an excellent overall of the inter-observer agreement of both observers for the standardized reporting system of acute appendicitis (K = 0.89, 95 % CI = 0.87-0.92, P = 0.001). There was good inter-observer agreement for visualization of the appendix (K = 0.78, P = 0.001), the tip diameter (K = 0.75, P = 0.001), and a single wall thickness of appendix (K = 0.77, P = 0.001). There was excellent inter-observer agreement for outer to outer wall diameter (K = 0.82, P = 0.001), mucosal hyper-enhancement (K = 0.80, P = 0.001), appendicolith (K = 0.86, P = 0.001), gas in the appendix (K = 0.82, P = 0.001), surrounding fat stranding (K = 0.81, P = 0.001), focal cecal thickening (K = 0.85, P = 0.001), peri-appendiceal air (K = 0.87, P = 0.001), peri-appendicular fluid collection, phlegmon, or abscess (K = 0.82, P = 0.001), and right ovary cyst (K = 0.83, P = 0.001).
Conclusion: we concluded that excellent reliability of a standardized reporting system of acute appendicitis in the adults using low-dose 320-rows CT.

1. Introduction

Acute appendicitis is the leading cause of acute abdominal surgery, with an estimated lifetime risk of 7–12 %. Acute appendicitis is the most common cause of right lower quadrant pain presenting to the emergency department and remains the most frequent indication for urgent abdominal surgery. Early surgical intervention was preferred, and negative appendectomy rates between 10–40 % were routinely accepted to avoid delayed diagnosis and the risk of perforated appendicitis. Before the advent of advanced imaging, the diagnosis of appendicitis was based on clinical symptoms [1–3]. Diagnosis of appendicitis is suspected, a number of radiologic modalities may improve patient outcomes [4–8]. Ultrasound is favored by some physicians but it has lower sensitivity and limited by operator dependence, patient body habitus [9]. Many researchers have also tried to use color Doppler imaging to detect blood flow in the wall of the appendix, but this has shown only a marginal increase in the sensitivity to 87 % for detecting acute appendicitis [10]. Elastography is recently applied to assess appendicitis but it is in early stages [11]. MR imaging can diagnose acute appendicitis but it has relatively long examination time and limited accessibility [12–14].

Computed tomography (CT) has a significant role in the diagnosis of acute appendicitis as it provides comprehensive information about the appendix, and peril-appendicular changes [15–18]. In most cases, CT simultaneously shows multiple findings, enabling a confident diagnosis of appendicitis. However, in some cases, CT findings are equivocal or inconclusive, but there is a high clinical suspicion for acute appendicitis. This subset of patients with indeterminate or equivocal imaging findings has been estimated to represent 9–13 % of CT studies for workup of acute appendicitis, with up to 30 % of these patients being subsequently diagnosed as appendicitis [19–22]. Different ultrasound scoring system applied for the prediction of acute appendicitis [23,24]. Also, few studies reported the role of different scoring systems of CT in the diagnosis of acute appendicitis [25–30]. The standardized reporting system of acute appendicitis using CT was developed for the diagnosis of acute appendicitis in patients with abdominal pain [25,26]. Few studies discuss the role of low-dose CT in the assessment of patients with suspected acute appendicitis [30–33]. The unique of this study

* Corresponding author at: Department of Diagnostic Radiology, Mansoura Faculty of medicine, Elgomheryia street, Mansoura, 3512, Egypt.
E-mail address: arazek@mans.edu.eg (A.A.K. Abdel Razek).

https://doi.org/10.1016/j.ejro.2019.11.001
Received 3 October 2019; Received in revised form 1 November 2019; Accepted 2 November 2019
Available online 14 November 2019
2352-0477/ © 2019 The Author(s). Published by Elsevier Ltd. This is an open access article under the CC BY-NC-ND license (http://creativecommons.org/licenses/BY-NC-ND/4.0/).

Table 1
Inter-observer agreement of standardized reporting system of acute appendicitis at low-dose 320-rows CT.

Imaging Findings	Observer 1	Observer 2	K	95% CI	P value	Percent agreement
Visualized appendix	74	72	0.78	0.502-1.0	0.001	97.44
Outer-outer wall diameter						
6-10 mm	36	35	0.82	0.69-0.95	0.001	91.03
> 10 mm	37	38				
Tip diameter						
6-10 mm	28	33	0.75	0.61-0.90	0.001	88.16
> 10 mm	48	43				
Single wall thickness						
≤ 3 mm	33	25	0.77	0.63-0.92	0.001	89.19
> 3 mm	40	49				
Mucosal	61	62	0.80	0.65-0.97	0.001	93.60
Hyper-enhancement						
Appendicolith	20	16	0.86	0.72-0.99	0.001	94.87
Gas in lumen of appendix	16	12	0.82	0.66-0.98	0.001	94.74
Fat stranding	59	55	0.81	0.66-0.95	0.001	92.31
Focal cecal thickening	14	11	0.85	0.70-1.0	0.001	96.15
Peri-appendiceal air	10	8	0.87	0.70-1.0	0.001	97.44
Peri-appendicular collection, phlegmon, or abscess	16	12	0.82	0.66-0.98	0.001	94.74
Right ovary cyst	18	16	0.83	0.61-1.0	0.001	92.31
Overall			0.89	0.87-0.92	0.001	91.30

using a low-dose 320-rows CT for diagnosis of acute appendicitis in the adults with a standardized reporting system.

The **aim of this work** is to assess the reliability of a standardized reporting system of acute appendicitis in adults at low-dose 320-rows CT.

2. Material and methods

2.1. Patients

The study was approved by the institutional review board and informed consent from the patients was waived because this is a retrospective study. The inclusion criteria were patients with pathologically proved acute appendicitis that underwent low-dose 320-rows CT of the abdomen and pelvis. The patients in this study were 87 patients (40 male and 38 female) with a mean age of 45 years (20–65 years) that presented with right lower quadrant abdominal pain (n = 78), fever (n = 69) and vomiting (n = 65).

2.2. CT technique

The study was done at CT scanner machines (320 slices Aquilion One Aquilion ONE, Toshiba Medical Systems; Japan). Positive oral contrast was given 2 h before study and scout film as done before contrast medium injection. Imaging was perfumed 65 s after intravenous injection of 100 ml of contrast medium (Omnipaque 350, GE Healthcare) at a rate of 4 ml/s. Scanning settings include an Adaptive Iterative Dose Reduction three dimensional (AIDR-3D) with tube voltage Kv (100) and automatic mAs (200–300 according to the patient), pitch, 0.7; and rotation time, 0.5 s. The scanning was extending from the hepatic dome till the symphysis pubis at the portal venous phase. The images are reconstructed at a slice thickness of 2.5 mm.

2.3. Image analysis

The CT image analysis was performed by 2 radiologists (AA, MS) who were experts in the abdominal imaging for 25 and 5 years respectively who were blinded to the clinical presentation and surgical findings of the patients. The image analysis was done using the axial, coronal and sagittal reformatted images on PACS workstations according to a standardized reporting system of acute appendicitis. The outer to the outer wall diameter of the appendix was classified into less than 6 mm; 6 − 10 mm; and more than 10 mm; the tip diameter of the appendix was classified into less than 6 mm; 6 − 10 mm; and more than 10 mm, single wall thickness of the dilated appendix was classified into less than or equal to 3 mm ; and more than 3 mm, presence or absence of mucosal hyper-enhancement of the appendix, appendicolith, gas in the lumen of the appendix, presence of peri-appendiceal fat stranding, focal cecal thickening, peri-appendiceal air, peri-appendicular fluid collection, and right ovary abnormality.

2.4. Statistical analysis

The statistical analysis of data was done by using SPSS program (Statistical package for social science version 22). The weighted kappa statistic (*K*) including 95 % confidence interval (*CI*) with percentage agreement was made to estimate the proportion of agreement for imaging findings and overall findings of a standardized reporting system of acute appendicitis using low dose CT of both reviewers. The *K* values were interpreted as follows: *k* values between 0.61 and 0.80 represented good; *k* values between 0.81 and 1.00 represented excellent. A (*P*) value of less than 0.05 indicated a statistically significant difference.

3. Results

Table 1 shows the inter-observer agreement of the CT standardized reporting system of acute appendicitis. The reporting standards of acute appendicitis by both observers were visualization of the appendix (n = 7472) (Fig. 1**)**, the outer to the outer wall diameter of the appendix was 6 − 10 mm (n = 36, 35), more than 10 mm (n = 3837) (Fig. 2**)**, the tip diameter of the appendix was 6 − 10 mm (n = 28, 33) and more than 10 mm (n = 4843) (Fig. 3), single wall thickness of the dilated appendix ≤ 3 mm (n = 33, 25) and > 3 mm (n = 4049) (Fig. 4), mucosal hyper-enhancement (n = 6162) (Fig. 5), peri-appendiceal fat stranding (n = 59, 55) (Fig. 6), appendicolith (n = 2016) (Fig. 7), focal cecal thickening (n = 1411) (Fig. 8), peri-appendiceal air (n = 108) (Fig. 9), peri-appendicular fluid collection (n = 1612) (Fig. 10), gas in the lumen of the appendix (n = 1612) (Fig. 11), and the presence of right ovarian cyst (n = 1816).

The percent agreement of both observers for visualization of the appendix was 97.4 %, the outer to the outer wall diameter of the appendix was 91.03 %, the tip diameter of the appendix was 88.16 %, the single wall thickness of the dilated appendix was 89.19 %, mucosal hyper-enhancement was 93.6 %, surrounding peri-appendiceal fat stranding or thickening of the pararenal or latero-conal fascia was

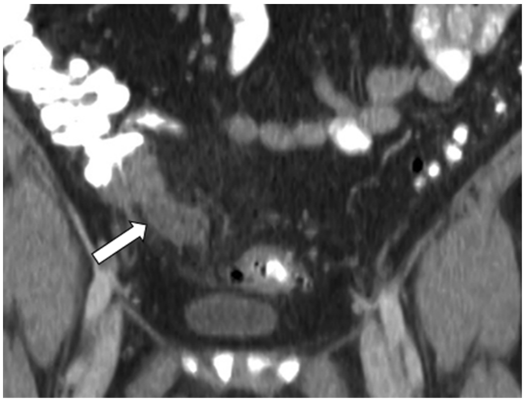

Fig. 1. *Visualization of the appendix:* Coronal contrast CT scan shows distended appendix (arrow) in a patient with acute appendicitis.

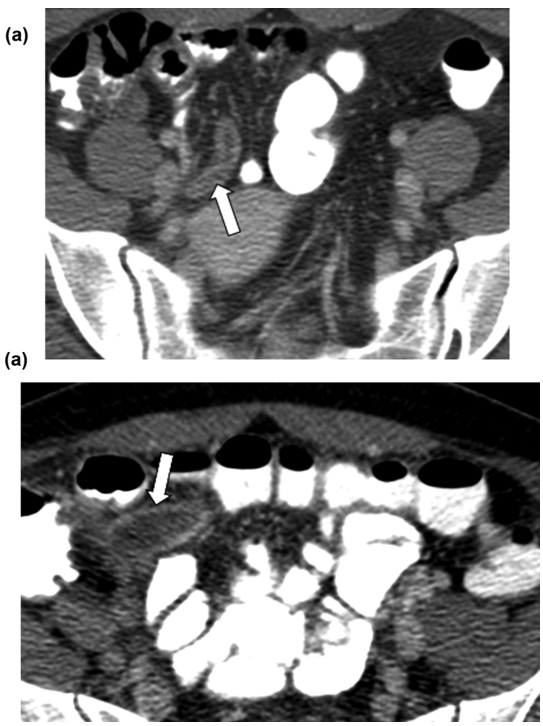

Fig. 2. *Outer to outer diameter of the appendix:* (a) axial CT scan shows distended appendix with outer to outer diameter less than 10 mm (arrow). (b): axial CT shows in another patient shows the outer diameter of the appendix more than 10 mm (arrow).

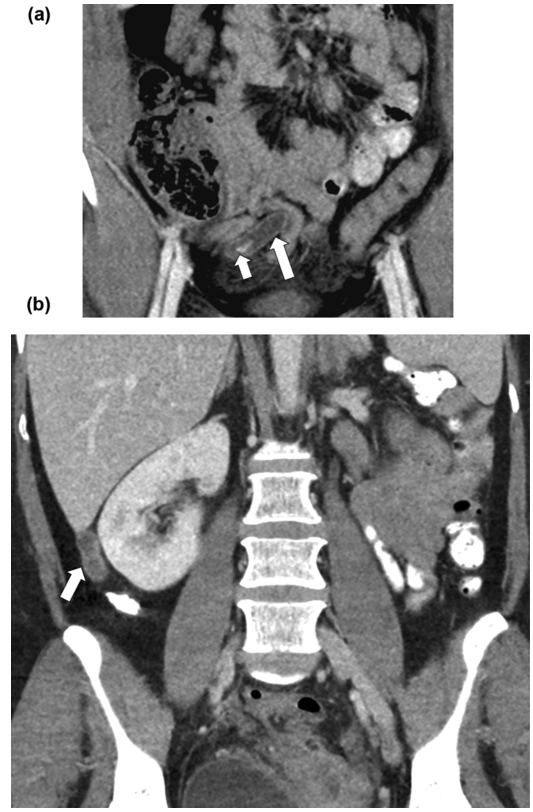

Fig. 3. *Tip diameter of the appendix:* (a) axial CT scan shows distended appendix with a tip diameter less than 3mm (arrow). (b): coronal CT scan in another patient shows distended appendix with a tip diameter more than 3mm (arrow).

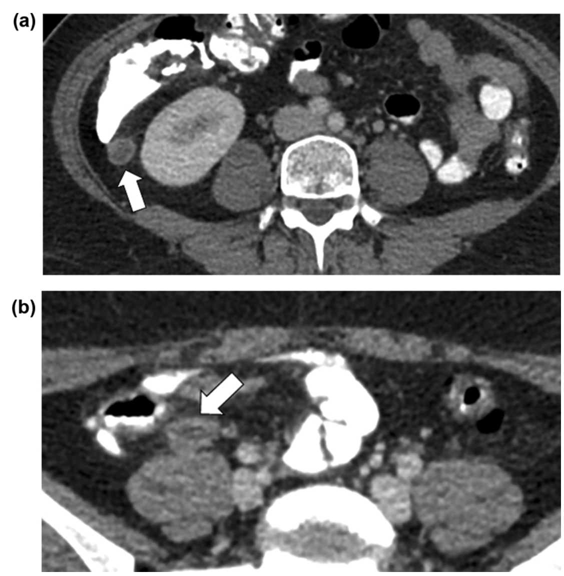

Fig. 4. *Single wall thickness of the dilated appendix:* (a) axial CT scan shows a single wall thickness of the appendix less than 3 mm. (b): axial CT scan of another patient shows a single wall thickness of the appendix more than 3 mm.

92.31 %, appendicolith was 94.87 %, focal cecal thickening at the base of the appendix was 96.15 %, peri-appendiceal air 97.44 %, the presence of right lower quadrant fluid collection, phlegmon, or abscess was 94.74 %, gas in the lumen of the appendix was 94.74 %, and the presence of right ovarian cyst was 92.31 %. The overall percent agreement of both reviewers for the CT standardized reporting system of acute appendicitis was 91.83 %.

There was overall excellent inter-observer agreement of CT standardized reporting system of acute appendicitis (K = 0.89, 95 % CI = 0.87-0.92, P = 0.001). There was good inter-observer agreement for visualization of the appendix (K = 0.78, CI = 0.502–1.0, P = 0.001); the outer to the outer wall diameter (K = 0.82, CI = 0.69-0.95, P = 0.001); the tip diameter of the appendix (K = 0.75, CI = 0.61-0.90, P = 0.001); and single wall thickness of the dilated appendix (K = 0.77, CI = 0.63-0.92, P = 0.001). There was excellent inter-observer agreement for mucosal hyper-enhancement (K = 0.80, CI = 0.65-0.97, P = 0.001); peri-appendicular fat stranding (K = 0.81, CI = 0.66-0.95, P = 0.001); appendicolith (K = 0.86, CI = 0.72-0.99, P = 0.001); focal cecal thickening (K = 0.85, CI = 0.70–1.0, P = 0.001); peri-appendiceal air (K = 0.87, CI = 0.70–1.0, P = 0.001); peri-appendicular fluid collection (K = 0.82, CI = 0.66-0.98, P = 0.001); gas in the lumen of the appendix (K = 0.82, CI = 0.66-0.98, P = 0.001); and right ovarian cyst (K = 0.831, CI = 0.61–1.0, P = 0.001).

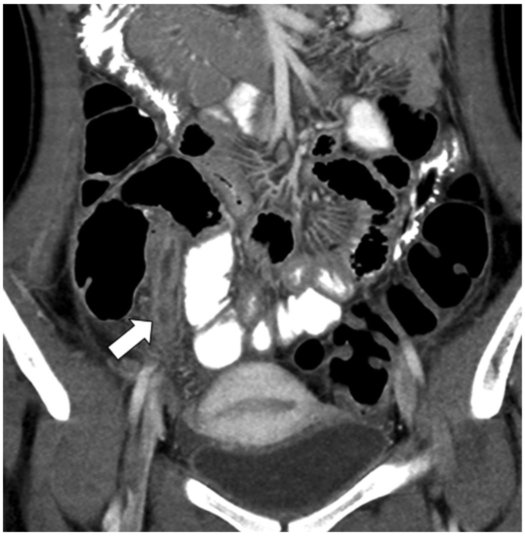

Fig. 5. *Mucosal hyper-enhancement:* coronal CT scan shows marginal enhancement of the inflamed appendix (arrow).

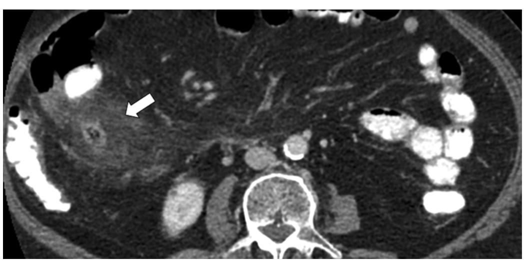

Fig. 6. *fat stranding or thickening of the para-renal or latero-conal fascia:* axial CT scan shows inflamed appendix with marked peri-appendicular fat stranding.

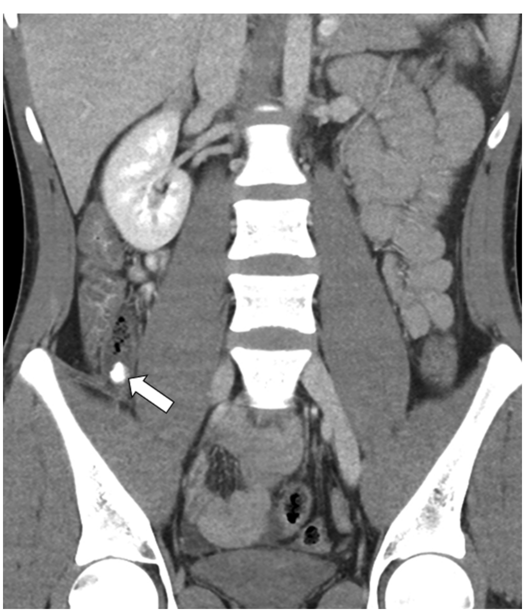

Fig. 7. *Appendicolith:* coronal CT scan shows dense calcified appendicolith (arrow).

4. Discussion

The main findings in this manuscript are an excellent inter-observer agreement of both observers for a standardized reporting system of acute appendicitis. There is a good inter-observer agreement for

Fig. 8. *Focal cecal thickening at the base:* coronal CT scan shows focal thickening of the cecum (arrow) adjacent to the appendix.

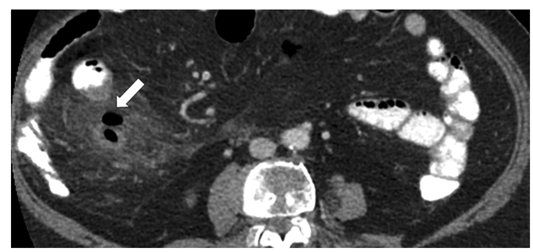

Fig. 9. *Peri-appendiceal air:* axial CT scan shows perforated appendix with peri-appendicular air (arrow) associated with fat stranding.

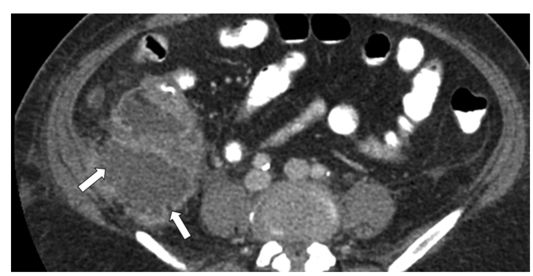

Fig. 10. *Right lower quadrant abscess:* axial CT scan shows localized fluid collection (arrow) with marginal enhancement and loculation in patient with acute appendicitis.

visualization of the appendix, the outer-outer wall diameter, the tip diameter, single wall thickness, mucosal hyper-enhancement, surrounding fat stranding, appendicolith, focal cecal thickening at the base, presence of peri-appendiceal air, phlegmon, or abscess, gas in the lumen of the appendix, and right ovary abnormality.

The importance of this study is increased confidence about diagnosis of acute appendicitis as combined CT findings and signs of acute appendicitis are more confident than the presence of single separate findings of acute appendicitis. In addition, the combined features are more specific, sensitive and accurate in diagnosis of acute appendicitis in the clinical practice. Previous studies reported that the individual CT findings of acute appendicitis are non-specific with limited accuracy and sensitivity in diagnosis of acute appendicitis [15–22].

Another issue about the real importance of this study is the impact of this standardized scoring system of acute appendicitis on patient management. In this study, the presence of multiple imaging findings such as peri-appendiceal air, phlegmon, or abscess, gas in the lumen of

Fig. 11. *Gas in lumen of the appendix:* axial CT scan shows gas (arrow) is seen in the lumen of the inflamed appendix.

the appendix in our work resulted in high reproducibility and achieved high diagnostic accuracy to suspect complicated and perforated appendix. Previous studies reported that patients with acute appendicitis require either medical or surgical treatment according to the clinical status and the CT findings of the patients. A multidisciplinary approach of clinical, surgeon and radiologist is recommended for selection of best management management of adult patients with acute appendicitis. Prediction of complicated or perforated appendicitis is important for urgent surgical management [17–23]. Further studies are recommended to assess the severity and course of the disease with standard reporting system

In this study, the inter-observer agreement is good for visualization of the appendix, tip diameter, and single wall thickness. The previous study reported that the appendix was visualized on CT in 89 patients, of whom 71 (80 %) had pathologically proven appendicitis [25]. Another studied added that increased appendiceal caliber alone is not a reliable indicator of appendicitis and must be considered alongside the patient's clinical history and other imaging findings to avoid misdiagnosis [4–8]. Imaging findings associated with appendicitis included appendiceal diameter (odds ratio = 14; $p = 0.002$), and appendiceal mucosal hyper-enhancement (odds ratio = 8.7; $p < 0.001$) [25]. Recent articles have suggested that the wall thickness of the appendix is a more reliable measurement than an appendiceal diameter [1]. The appendiceal mucosal wall enhancement is defined as attenuation of the appendiceal wall that is subjectively equal to or greater than that of the normal bowel wall [4–7]. An increase in the appendiceal caliber between the serial CT scans, even in the absence of adjacent fat stranding, may represent a sign of early-stage acute appendicitis.

In this study, there is an excellent inter-observer agreement of appendicolith and the presence of gas or contrast medium within the lumen of the appendix. Previous studies reported that appendicolith is a well-defined, hyperdense non-enhancing structure that strongly associated with advanced appendicitis and is a risk factor for perforation and necrosis [24–28]. Another studies reported that the presence of gas within the lumen of the appendix is a sign of acute appendicitis and the presence of the oral contrast material within the appendix conflicts with a diagnosis of acute appendicitis and can be used as supporting evidence for non-obstructed appendix in equivocal cases [24–28].

In this study, there is an excellent inter-observer agreement of the presence of peri-appendicular fat stranding, fluid collection, and focal cecal thickening. Phlegmon is defined as diffuse and substantial inflammation of the peri-appendiceal fat with ill-defined but not rim-enhancing fluid collections and an abscess is defined as a discrete collection with a rim enhancement [15–17]. Another study added that the peri-appendiceal fluid collection revealed area under the curve of 0.80, the sensitivity of 77 %, and an accuracy of 80 % and the highest specificity (100 %) is recorded for the presence of the extraluminal air and a perityphlitic abscess [27]. Another study added that the peri-appendiceal fat stranding is the only feature with high sensitivity (94 %) for the diagnosis of acute appendicitis [17]. Previous studies reported that the presence of gas in the surrounding peri-appendicular tissue is a sign of acute appendicitis. The extra-luminal gas is defined as a focal area of free gas outside of the bowel lumen [4–7]. The Key CT findings involving the cecum involve the cecal apex and include the cecal apical thickening, the arrowhead sign, and the cecal bar sign [5–8].

The CT standardized reporting system for acute appendicitis has many advantages. Firstly, this reporting system provides a common language between the radiologists, clinician, and the surgeons to have a common language for a better patient management and care. Secondly, this system is simple and reliable to apply in clinical practice.

This study was conducted upon a 320 multi-detectors scanners using low dose CT software (ADIR-3D) and a low dose of contrast medium. Previous studies reported that application of a 320- multi-detectors computed tomography associated with short examination time and using a low amount of contrast material [30–32]. The CT images are reconstructed with ADIR-3D which improves spatial resolution and reduction of the noise levels and the radiation dose. The ADIR-3D is a reconstruction algorithm to improve the image noise and has shown to reduce the radiation dose in clinical practice [31–34].

This study has a few limitations. First; this study was a retrospective study done on a small number of patients. Further prospective multicenter studies upon a large number of patients are recommended. Second; this study applied CT for a standardized reporting system of acute appendicitis. Further studies using routine and diffusion-weighted imaging and comparing with CT for a standardized reporting system of acute appendicitis are recommended.

5. Conclusion

We concluded that the excellent reliability of a standardized reporting system of acute appendicitis in adults using low-dose 320-rows CT.

Declaration of Competing Interest

The authors have no conflicts of interest. This includes financial or personal relationships that inappropriately influence (bias) his or her actions.

References

[1] C. Athanasiou, S. Lockwood, G.A. Markides, Systematic review and meta-analysis of laparoscopic versus open appendicectomy in adults with complicated appendicitis: an update of the literature, World J. Surg. 41 (2017) 3083–3099.

[2] H.E. Sammalkorpi, P. Mentula, H. Savolainen, A. Leppäniemi, The introduction of adult appendicitis score reduced negative appendectomy rate, Scand. J. Surg. 106 (2017) 196–201.

[3] T. Bax, M. Macha, J. Mayberry, The utility of CT scan for the diagnostic evaluation of acute abdominal pain, Am. J. Surg. 217 (2019) 959–966.

[4] Expert Panel on Gastrointestinal Imaging, E.M. Garcia, M.A. Camacho, D.R. Karolyi, D.H. Kim, B.D. Cash, et al., ACR appropriateness criteria (®) right lower quadrant pain-suspected appendicitis, J. Am. Coll. Radiol. 15 (2018) S373–87.

[5] K.A. Eng, A. Abadeh, C. Ligocki, Y.K. Lee, R. Moineddin, T. Adams-Webber, et al., Acute appendicitis: a meta-analysis of the diagnostic accuracy of US, CT, and MRI as second-line imaging tests after an initial US, Radiology 288 (2018) 717–727.

[6] H. Toprak, T.F. Yilmaz, S. Yildiz, I. Turkmen, S. Kurtcan, Mimics of acute appendicitis-Alternative diagnoses at sonography, CT, and MRI; specific imaging findings that can help in differential diagnosis, Clin. Imaging 48 (2018) 90–105.

[7] D.W. Swenson, R.S. Ayyala, C. Sams, E.Y. Lee, Practical imaging strategies for acute appendicitis in children, AJR Am. J. Roentgenol. 211 (2018) 901–909.

[8] L. Malia, J.J. Sturm, S.R. Smith, R.T. Brown, B. Campbell, H. Chicaiza, Diagnostic accuracy of laboratory and ultrasound findings in patients with a non-visualized appendix, Am. J. Emerg. Med. 37 (2019) 879–883.

[9] J.H. Woo, J.J. Jeon, S.J. Choi, J.Y. Choi, Y.S. Jang, Y.S. Lim, et al., Low-dose (2-mSv) computed tomography for suspected appendicitis: applicability in an emergency department, Am. J. Emerg. Med. 36 (2018) 2139–2143.

[10] T. Nishizawa, S. Maeda, R.D. Goldman, H. Hayashi, Predicting need for additional CT scan in children with a non-diagnostic ultrasound for appendicitis in the emergency department, Am. J. Emerg. Med. 36 (2018) 49–55.
[11] Y. Xu, R.B. Jeffrey, L.K. Shin, M.A. DiMaio, E.W. Olcott, Color doppler imaging of the appendix: criteria to improve specificity for appendicitis in the borderline-size appendix, J. Ultrasound Med. 35 (2016) 2129–2138.
[12] C. Göya, C. Hamidi, M.H. Okur, M. Içer, A. Oğuz, S. Hattapoğlu, et al., The utility of acoustic radiation force impulse imaging in diagnosing acute appendicitis and staging its severity, Diagn. Interv. Radiol. 20 (2014) 453–458.
[13] J.D. Covelli, S.P. Madireddi, L.A. May, J.E. Costello, C.J. Lisanti, C.L. Carlson, MRI for pediatric appendicitis in an adult-focused general hospital: a clinical effectiveness study-challenges and lessons learned, AJR Am. J. Roentgenol. 212 (2019) 180–187.
[14] M.D. Repplinger, P.J. Pickhardt, J.B. Robbins, D.R. Kitchin, T.J. Ziemlewicz, S.J. Hetzel, et al., Prospective comparison of the diagnostic accuracy of MR imaging versus CT for acute appendicitis, Radiology 288 (2018) 467–475.
[15] O. Özdemir, Y. Metin, N.O. Metin, A. Küpeli, S. Kalcan, F. Taşçı, Contribution of diffusion-weighted MR imaging in follow-up of inflammatory appendiceal mass: preliminary results and review of the literature, Eur. J. Radiol. Open 3 (2016) 207–215.
[16] R. Quadri, V. Vasan, C. Hester, M. Porembka, J. Fielding, Comprehensive review of typical and atypical pathology of the appendix on CT: cases with clinical implications, Clin. Imaging 53 (2019) 65–77.
[17] H.Y. Kim, J.H. Park, Y.J. Lee, S.S. Lee, J.J. Jeon, K.H. Lee, Systematic review and meta-analysis of CT features for differentiating complicated and uncomplicated appendicitis, Radiology 287 (2018) 104–115.
[18] W.D. Foley, CT features for complicated versus uncomplicated appendicitis: what is the evidence? Radiology 287 (2018) 116–118.
[19] P.A. Poletti, D. Botsikas, M. Becker, M. Picarra, O.T. Rutschmann, N.C. Buchs, et al., Suspicion of appendicitis in pregnant women: emergency evaluation by sonography and low-dose CT with oral contrast, Eur. Radiol. 29 (2019) 345–352.
[20] J.H. Woo, J.J. Jeon, S.J. Choi, J.Y. Choi, Y.S. Jang, Y.S. Lim, et al., Low-dose (2-mSv) computed tomography for suspected appendicitis: applicability in an emergency department, Am. J. Emerg. Med. 36 (2018) 2139–2143.
[21] A. Srinivasan, S. Servaes, A. Peña, K. Darge, Utility of CT after sonography for suspected appendicitis in children: integration of a clinical scoring system with a staged imaging protocol, Emerg. Radiol. 22 (2015) 31–42.
[22] J.H. Park, J.J. Jeon, S.S. Lee, A.C. Dhanantwari, J.Y. Sim, H.Y. Kim, et al., Can we perform CT of the appendix with less than 1 mSv? A de-escalating dose-simulation study, Eur. Radiol. 28 (2018) 1826–1834.
[23] A. Kılınçer, E. Akpınar, B. Erbil, E. Ünal, A.D. Karaosmanoğlu, V. Kaynaroğlu, et al., A new technique for the diagnosis of acute appendicitis: abdominal CT with compression to the right lower quadrant, Eur. Radiol. 27 (2017) 3317–3325.
[24] S.C. Fallon, R.C. Orth, R.P. Guillerman, M.M. Munden, W. Zhang, S.C. Elder, et al., Development and validation of an ultrasound scoring system for children with suspected acute appendicitis, Pediatr. Radiol. 45 (2015) 1945–1952.
[25] R. Sola Jr, S.B. Theut, K.A. Sinclair, D.C. Rivard, K.M. Johnson, H. Zhu, et al., Standardized reporting of appendicitis-related findings improves reliability of ultrasound in diagnosing appendicitis in children, J. Pediatr. Surg. 53 (2018) 984–987.
[26] B.D. Godwin, F.T. Drake, V.V. Simianu, J.E. Shriki, D.S. Hippe, M. Dighe, et al., A novel reporting system to improve accuracy in appendicitis imaging, AJR Am. J. Roentgenol. 204 (2015) 1212–1219.
[27] V.V. Simianu, A. Shamitoff, D.S. Hippe, B.D. Godwin, J.E. Shriki, F.T. Drake, et al., The reliability of a standardized reporting system for the diagnosis of appendicitis, Curr. Probl. Diagn. Radiol. 46 (2017) 267–274.
[28] M. Avanesov, N.J. Wiese, M. Karul, H. Guerreiro, S. Keller, P. Busch, et al., Diagnostic prediction of complicated appendicitis by combined clinical and radiological appendicitis severity index (APSI), Eur. Radiol. 28 (2018) 3601–3610.
[29] M. Mannil, C. Polysopoulos, D. Weishaupt, A. Hansmann, Clinical-radiological scoring system for enhanced diagnosis of acute appendicitis, Eur. J. Radiol. 98 (2018) 174–178.
[30] E. Blumfield, D. Yang, J. Grossman, Scoring system for differentiating perforated and non-perforated pediatric appendicitis, Emerg. Radiol. 24 (2017) 547–554.
[31] S.J. Yun, C.W. Ryu, N.Y. Choi, H.C. Kim, J.Y. Oh, D.M. Yang, Comparison of low- and standard-dose CT for the diagnosis of acute appendicitis: a meta-analysis, AJR Am. J. Roentgenol. 208 (2017) W198–207.
[32] C. Storz, M. Kolb, J.H. Kim, J. Weiss, W.G. Kunz, K. Nikolaou, et al., Impact of radiation dose reduction in abdominal computed tomography on diagnostic accuracy and diagnostic performance in patients with suspected appendicitis: an intraindividual comparison, Acad. Radiol. 25 (2018) 309–316.
[33] M. Jin, T.R. Sanchez, R. Lamba, G. Fananapazir, M.T. Corwin, Accuracy and radiation dose reduction of limited-range CT in the evaluation of acute appendicitis in pediatric patients, AJR Am. J. Roentgenol. 209 (2017) 643–647.
[34] A. Nakamoto, K. Yamamoto, M. Sakane, G. Nakai, A. Higashiyama, H. Juri, et al., Reduction of the radiation dose and the amount of contrast material in hepatic dynamic CT using low tube voltage and adaptive iterative dose reduction 3-dimensional, Medicine 97 (2018) e11857.