Reliability of Standardized Reporting System of acute appendicitis in adults at low-dose 320-rows CT

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Abstract

Aim: To assess reliability of standardized reporting system of acute appendicitis at low-dose 320-rows CT. **Methods:** Retrospective analysis CT of 78 patients with pathologically proven acute appendicitis. The study was performed at low-dose 320-rows CT. The image analysis was performed by 2 radiologists according to standardized reporting system of acute appendicitis. **Results:** There was excellent overall of inter-observer agreement of both observers for 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 appendix ($K = 0.78$, $P = 0.001$), tip diameter ($K = 0.75$, $P = 0.001$), and 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 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 standardized reporting system of acute appendicitis in adults using low-dose 320-rows CT.

Background

Acute appendicitis is the leading cause for 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 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 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 diagnosis of acute appendicitis as it provides comprehensive information about the appendix, and peri-appendicular changes **(15-18)**. In most cases, CT simultaneously shows multiple findings, enabling confident diagnosis of appendicitis. However, in some cases, CT findings are equivocal or inconclusive, but there is high clinical suspicion for appendicitis. This subset of patients with indeterminate or equivocal imaging findings has been estimated to represent 9–13% of CT studies for workup of appendicitis, with up to 30% of these patients

being subsequently diagnosed with appendicitis **(19-22)**. Different ultrasound scoring system applied for prediction of appendicitis **(23-24)**. Also, few studies reported a role of different scoring system of CT in diagnosis of acute appendicitis **(25-30)**. Standardized reporting system of acute appendicitis using CT with developed for diagnosis of acute appendicitis in patients with abdominal pain **(25-26)**. Few studies discuss the role of low-dose CT in assessment of patients with suspected acute appendicitis **(30-33)**. The unique of this study using low-dose 320-rows CT for diagnosis of acute appendicitis with standardized reporting system.

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

Methods

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 was 87 patients (40 male and 38 female) with 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).

CT Technique

The study was done at CT scanner machines (320 slice Aquilion One Aquilion ONE, Toshiba Medical Systems; Japan). Positive oral contrast was given 2 hours before study and scout film as done before contrast medium injection. Imaging was performed 65 seconds 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 second. The scanning was extending from hepatic dome till the symphysis pubis at the portal venous phase. The images are reconstructed at thickness 2.5mm.

Image analysis

The CT image analysis was performed by 2 radiologists (AA, MS) who were expert in abdominal imaging for 25 and 5 years respectively who were blinded to clinical presentation. The image analysis was done using axial, coronal and sagittal reformatted images on PACS workstations according to standardized

reporting system of acute appendicitis. The outer to outer wall diameter of appendix was classified into less than 6 mm; 6-10 mm; and more than 10 mm; tip diameter of appendix was classified into less than 6 mm; 6-10 mm; and more than 10 mm, single wall thickness of dilated appendix was classified into ≤ 3 mm ;>3 mm, presence or absence of mucosal hyper enhancement of appendix, appendicolith, gas in lumen of appendix, periappendiceal fat stranding, focal cecal thickening, peri-appendiceal air, peri-appendicular fluid collection, and right ovary abnormality.

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 standardized reporting system of acute appendicitis 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 less than 0.05 indicated a statistically significant difference with 95% confidence interval (CI).

Results

Table 1 shows inter-observer agreement of standardized reporting system of acute appendicitis. The reporting standards of acute appendicitis by both observers were visualization of appendix ($n = 74,72$) (**Fig.1**), outer to outer wall diameter of appendix was 6-10 mm ($n = 36, 35$), more than 10 mm ($n = 38,37$) (**Fig.2**), tip diameter of appendix was 6-10 mm ($n = 28, 33$) and more than 10 mm ($n = 48,43$) (**Fig.3**), single wall thickness of dilated appendix ≤ 3 mm ($n = 33, 25$) and > 3 mm ($n = 40,49$) (**Fig.4**), mucosal hyper-enhancement ($n = 61,62$) (**Fig.5**), peri-appendiceal fat stranding ($n = 59, 55$) (**Fig.6**), appendicolith ($n = 20,16$) (**Fig.7**), focal cecal thickening ($n = 14,11$) (**Fig.8**), peri-appendiceal air ($n = 10,8$) (**Fig.9**), peri-appendicular fluid collection ($n = 16,12$) (**Fig.10**), gas in lumen of appendix ($n = 16,12$) (**Fig.11**), right ovarian cyst ($n = 18,16$).

The percent agreement of both observers of visualization of appendix was 97.4 %, outer to outer wall diameter of appendix was 91.03%, tip diameter of appendix was 88.16 %, single wall thickness of dilated appendix was 89.19 %, mucosal hyper-enhancement was 93.6%, surrounding peri-appendiceal fat stranding or thickening of pararenal or lateroconal fascia was 92.31%, appendicolith was 94.87 %, focal cecal thickening at base was 96.15%, peri-appendiceal air 97.44 %, right lower quadrant fluid collection, phlegmon, or abscess was 94.74%, gas in lumen of appendix was 94.74%, and right ovary abnormality was 92.31 %. The overall percent agreement was 91.83%.

There was overall excellent inter-observer agreement of 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 appendix ($K = 0.78$, $CI = 0.502-1.0$, $P = 0.001$); outer to outer wall diameter ($K = 0.82$, $CI = 0.69-0.95$, $P = 0.001$); tip diameter ($K = 0.75$, $CI = 0.61-0.90$, $P = 0.001$); and single wall thickness of 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 appendix ($K = 0.82$, $CI = 0.66-0.98$, $P = 0.001$); and right ovary abnormality ($K = 0.831$, $CI = 0.61-1.0$, $P = 0.001$).

Discussion

The main findings in this manuscript are excellent inter-observer agreement of both observers for standardized reporting system of acute appendicitis. There is good inter-observer agreement of visualization of appendix, outer-outer wall diameter, tip diameter, Single wall thickness, mucosal hyper enhancement, surrounding fat stranding, appendicolith, focal cecal thickening at base, peri-appendiceal air, phlegmon, or abscess, gas in lumen of appendix, right ovary abnormality.

In this study, the inter-observer agreement was good for visualization of the appendix, tip diameter and single wall thickness. 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 wall thickness of the appendix is a more reliable measurement than appendiceal diameter (1). Appendiceal mucosal wall enhancement was defined as attenuation of the appendiceal wall that was subjectively equal to or greater than that of the normal bowel wall (4-7). An increase in appendiceal caliber between serial CT examinations, even in the absence of adjacent fat stranding, may signal early-stage acute appendicitis.

In this study, there is excellent inter-observer agreement of appendicolith and presence of gas or contrast medium within the lumen of appendix. Previous studies reported that appendicolith is 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 presence of gas within the lumen of appendix is a sign of acute appendicitis and the presence of oral contrast material within the appendix

conflicts with a diagnosis of acute appendicitis and can be used as supporting evidence for a non-obstructed appendix in equivocal cases **(24-28)**.

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

This study was conducted upon 320 multi-detectors scanner using low dose CT software (ADIR-3D) and low dose of contrast medium. Previous studies reported that application of 320-rows computed tomography associated with short examination time and using 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 image noise, and has shown to reduce the radiation dose in clinical practice **(31-35)**.

CT standard reporting system for acute appendicitis has many advantages. Firstly, this reporting system provides a common language between radiologists, clinician and surgeon to have a common language for better patient management and care. Secondly, this system is simple and reliable to apply in the clinical practice **(36-37)**.

This study has a few limitations. First; this study was retrospective study that done on small number of patients. Further prospective multicenter studies upon large number of patients are recommended. Second; this study applied CT for standardized reporting of acute appendicitis. Further studies using routine and diffusion MR imaging and comparing with CT for standardized reporting system of acute appendicitis are recommended **(38-40)**.

Conclusions

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

Abbreviations

CT - Computed tomography

ADIR-3D - Adaptive Iterative Dose Reduction three dimensional.

Declarations

Ethics approval and consent to participate

The study was approved by the local IRB of Ahmadi Hospital Kuwait and conforms to the ethical guidelines of the 1975 Declaration of Helsinki. Written informed consent was waived because this is a retrospective study.

Consent for publication

Not applicable.

Availability of data and material

All data are contained within the manuscript.

Competing interests

The authors declare that they have no competing interests.

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Authors' contributions

MSK analyzed and interpreted patient data and prepared manuscript; RA idea of manuscript and data and revised manuscript; AS contributed to preparation of manuscript; CV acquired and interpreted data and prepared manuscript; All authors read and approved the final manuscript.

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Non

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Tables

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 Hyper-enhancement	61	62	0.80	0.65- 0.97	0.001	93.60
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
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Figures

Figure 1

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

Figure 2

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

Figure 3

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

Figure 4

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

Figure 5

mucosal hyper enhancement: coronal CT scan shows marginal enhancement of inflamed appendix (arrow).

Figure 6

fat stranding or thickening of pararenal or lateroconal fascia: axial CT scan shows inflamed appendix with marked peri-appendicular fat stranding.

Figure 7

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

Figure 8

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

Figure 9

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

Figure 10

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

Figure 11

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