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Role of Ultrasound versus Computed Tomography in Diagnosis of Causes of Acute Abdominal Pain in a Child

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ABSTRACT

Background: The term acute abdomen refers to the sudden onset of severe abdominal pain requiring urgent medical or surgical treatment. O**bjective:** The aim of the present work was to compare the degree of current accuracy of abdominal ultrasound (US) and multi-detector row computed tomography (MDCT) in diagnosis of cases presented with acute abdomen in a child in Pediatric Assiut University Hospital, in order to optimize the radiologic diagnostic findings in relation to cost and time consumed. **Patients and methods:** This study was conducted retrospectively on 70 patients less than18 years old; 42(59.3%) males and 28 (40.7%) females. The mean age of participants was 9 (SD 3.63) years old. Those patients were presented to the emergency department (ED) in Pediatric Assiut University Hospital from April, 2017 to April 2018. **Results**: About 78% of cases presented by acute appendicitis; signs seen with US were matching to intraoperative findings, while 22% were not matching. Up to 70% of cases diagnosed as intestinal obstruction, a sign seen with US was matching to intraoperative findings, while 30% were not matching. Only 16.6% of cases diagnosed as perforated viscus, and signs seen with US were matching to intraoperative findings, while 83.3% were not matching. Only 3% of the participants in this study had non-diagnostic ultrasonography or a diagnostic dilemma. **Conclusion:** Although CT provides a diagnostic advantage over ultrasound, particularly in surgical instances, it should only be used in cases where the diagnosis is truly challenging due to radiation exposure risks. When acute appendicitis is suspected, the possibility of complicated appendicitis as in appendicular mass or abscess, or a perforated appendix should be excluded during US examination, otherwise plain MDCT is recommended.

Keywords: Ultrasound, Computed tomography, diagnosis, acute abdominal pain, children, retrospective study, case series, Assuit University**.**

INTRODUCTION

The term acute abdomen refers to the sudden onset of severe abdominal pain requiring urgent medical or surgical treatment. Acute abdominal pain is one of the most common complaints in children, and it poses a diagnostic challenge owing to the variety of underlying causes. Acute abdominal pain is usually a self-limiting, benign condition, such as in gastroenteritis, constipation, or viral illness **(1)**.

The clinical evaluation and care of patients who come with severe abdominal pain have undergone a significant transformation as a result of the increased availability and usage of CT and sonography **(2)**.

The principal method of assessing patients who appear with what was formerly described as a surgical abdomen has effectively been supplanted by these non-invasive imaging procedures, which have effectively replaced exploratory laparotomy **(2)**.

Sonography has become more often used to examine individuals with sudden abdominal pain over the past ten years. Sonography has some limitations despite being dynamic, non-invasive, quick, affordable, and widely available **(3)**. Sonography is more operator reliant than other radiologic methods and has a limited use in obese individuals since the ultrasonic beam cannot penetrate bone or gas. It also takes expertise, dedication, and experience from the operator **(4)**.

This prospective highlights various useful characteristics of using sonography on patients with severe abdominal discomfort. These considerations include the option of using sonography or CT as the initial examination method.

The aim of the present work was to compare the degree of current accuracy of abdominal ultrasound (US) and multi-detector row computed tomography (MDCT) in diagnosis of cases presented with acute abdomen in a child in Pediatric Assiut University Hospital, in order to optimize the radiologic diagnostic findings in relation to cost and time consumed.

PATIENTS AND METHODS

This study was conducted retrospectively on 70 patients less than18 years old; 42(59.3%) males and 28 (40.7%) females. The mean age of participants was 9 (SD 3.63) years old. Those patients were presented to the Emergency Department (ED) in Pediatric Assiut University Hospital from April, 2017 to April 2018.

The **inclusion criteria** for participation in the study were:

- Male and female children presenting with acute abdominal pain for more than 2 hours and less than 5 days at the ED of Pediatric Hospital at Assuit University Hospital.
- Patients subjected to abdominal US and MDCT of the abdomen in Radiology Department in Assiut University

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Hospital during the mentioned period and underwent surgical interference as a line of management or where subjected to medical treatment.

The **exclusion criteria** were patients older than 18, those with blunt or penetrating trauma, children who were released from the ED by the treating physician without any diagnostic imaging (US, CT, or plain radiographs), and patients who had haemorrhagic shock brought on by gastrointestinal bleeding or an acute abdominal aneurysm.

The study was carried retrospectively, where the intraoperative data and response to medical treatment were collected and then compared with the radiological outcome of the abdominal US and MDCT. Thereafter, statistical analysis was carried out to compare between the efficacies of each imaging modality in each presentation.

All patients were subjected to complete medical history uptake, complete clinical examination, abdominal US, MDCT examination of the abdomen, collection of the intraoperative data or the response to the medical treatment, and statistical evaluation of the efficacy of each imaging modality.

Techniques used in imaging

A. Ultrasound used techniques:

The graded-compression procedure; With this technique, interposing fat and bowel can be displaced or compressed by means of gradual compression to show underlying structures. Furthermore, if the bowel cannot be compressed, the noncompressibility itself is an indication of pathology (inflammation such as appendicitis, intussusception and malignancy or luminal distension resulting from obstruction) [(5)]**.**

Sonogrophically guided puncture; A little quantity of free fluid may develop in patients with acute abdomen in both surgical and non-surgical circumstances, making it non-specific. Knowing the type of fluid, however, can be beneficial [(6)].

B. CT used techniques:

Examination protocols: Patients who report to the emergency room with acute abdominal discomfort are scanned using the following parameters on an MDCT scanner: Slice collimation was 16 mm 0.75 mm, pitch was 1, tube voltage was 120 kV, and tube current was 225 mAs. A medium soft-tissue reconstruction kernel (B30f) and slices with a thickness of 2.0 mm (increment 1.0 mm) are typically employed for evaluation. To maximise diagnostic accuracy, the acquisition parameters must be optimised based on the current clinical diagnosis. For CT angiography, for instance, narrow collimation (1 mm slice thickness, 0.5 mm increment) is employed [(7)].

Sensitivity and specificity were determined using statistical methods and expert judgement, and the results of the US and CT was compared to the intraoperative findings.

Ethical Approval:

The study was approved by the Ethics Board of the Assiut University and an informed written consent was taken from the guardians of each participant in the study. This work has been carried out in accordance with The Code of Ethics of the World Medical Association (Declaration of Helsinki) for studies involving humans.

Statistical analysis

Data entry and data analysis were done using SPSS version 20 (Statistical Package for Social Sciences) and Excel 2007 program. Data were presented as number, percentage, mean and standard deviation. Sensitivity, specificity, positive and negative predictive values, and ROC curves were computed using Medcalc version 11.3 software. The sensitivity and specificity of the US findings were compared to that of the CT findings as a gold standard.

RESULTS

CT results were identical to intraoperative findings so the percentages which are illustrated in this study can be considered as ultrasound findings compared to CT findings. Figure 1 summarizes the age distribution of the participants of the study.

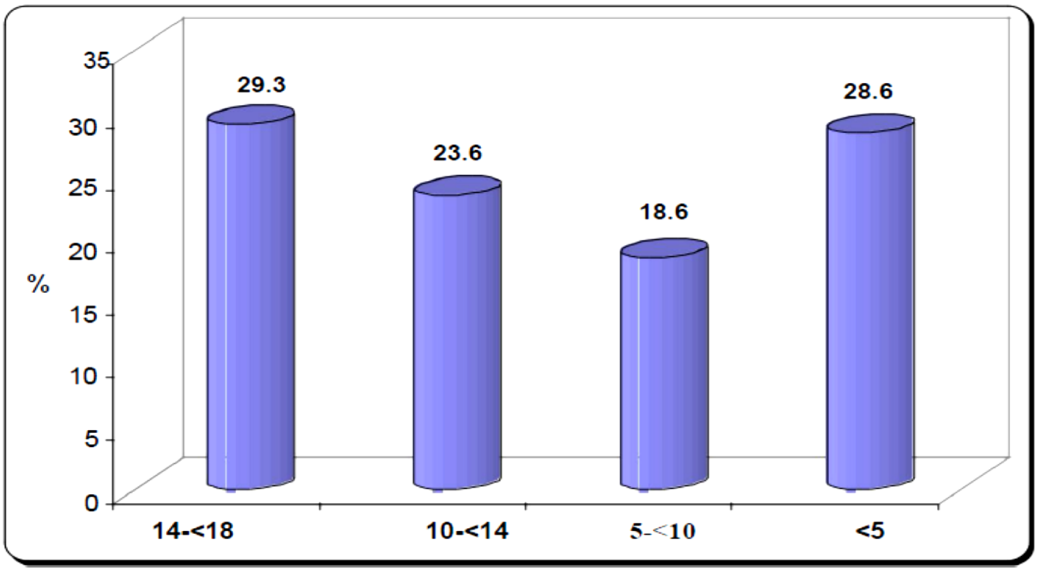


Figure (1): Age distribution among studied patients.

Table 1 shows the causes of acute abdomen, where acute appendicitis shows the highest percentage (35.7%) and localized abscess the least incidence (2.9%).

Table (1): Diagnosis of the participants of the study.

Diagnosis	No. (n= 70)	%
Acute appendicitis	25	35.7
Intestinal obstruction	20	28.6
Perforated viscous	12	17.1
Pancreatitis	6	8.6
Acute cholecystitis	5	7.1
Localized abscess	2	2.9

Table 2 shows that most cases of acute appendicitis were presented by right iliac pain, while only 8% were presented by other symptoms.

Table (2): Presentation of acute appendicitis of the participants of the study.

Presentation	No. (n= 25)	%
Typical	23	92
Atypical	2	8

Table 3 shows that almost all the cases included in the study with intestinal obstruction were presented typically with severe diffuse abdominal pain and history of gastroenteritis absolute constipation, which makes diagnosis of intestinal obstruction predicted clinically.

Table (3): Presentation of intestinal obstruction of the participants of the study.

Presentation	No. (n= 20)	%
Typical	18	90
Atypical	2	10

Table 4 shows that most cases of cholecystitis were presented with right hypochondrial pain, or obstructive jaundice, while the minority of cases was presented by other less common presentations e.g diffuse abdominal pain, epigastria pain, and recurrent attacks of vomiting.

Table (4): Presentation of acute cholecystis of the participants of the study.

Presentation	No. (n= 5)	%
Presented by right hypochondrial pain:		
Yes	4	80
No	1	20
Presented by obstructive jaundice:		
Yes	3	62.5
No	2	37.5

The next graph shows that the sensitivity of US in detection of Appendicular mass or abscess was 83.33%, and its specificity was 100% (Figure 2).

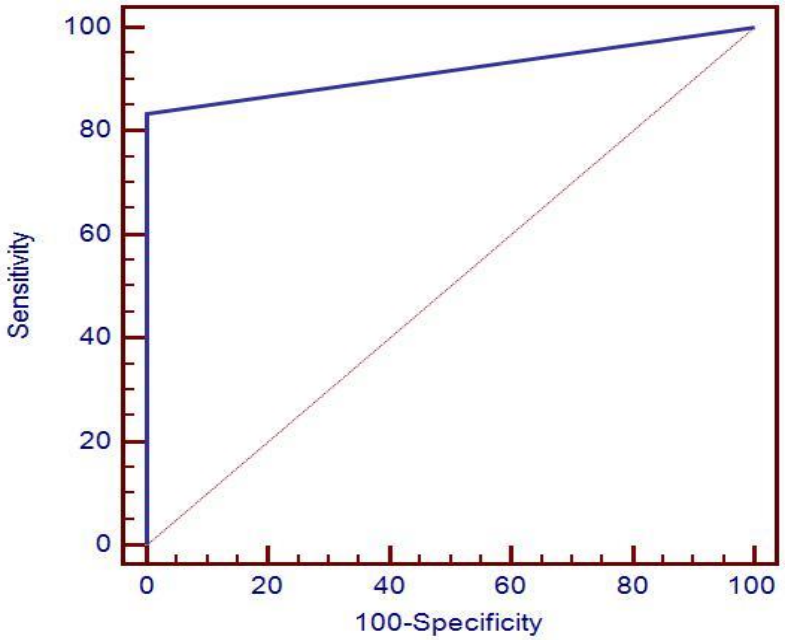


Figure 2: Appendicular mass (acute appendicitis)

Sensitivity	Specificity	+PV	-PV	AUC
83.33	100	100	95	0.917

The next graph shows that the sensitivity of US in detection of perforated appendix was 45 %, while its specificity was 100% (Figure 3)

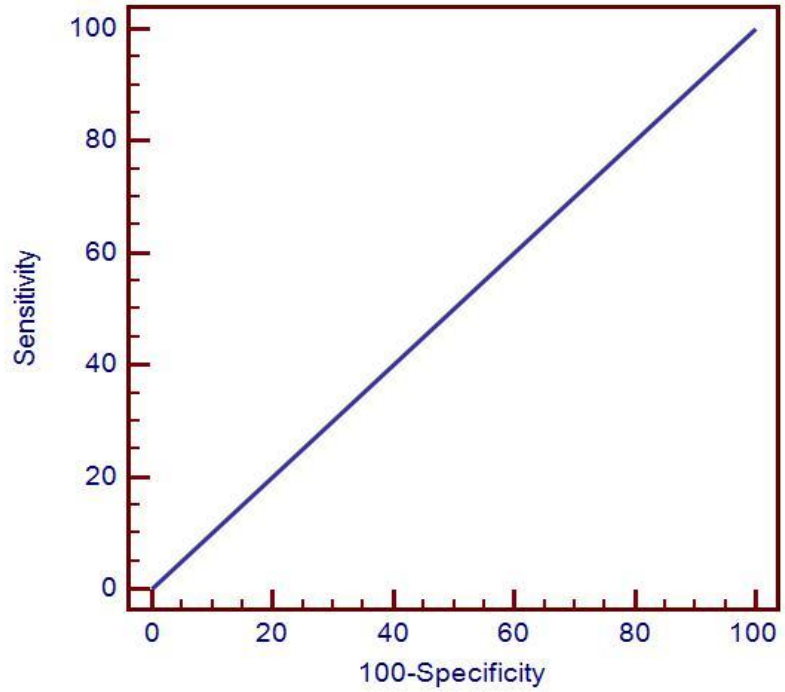


Figure 3: Perforated appendix in acute appendicitis

Sensitivity	Specificity	+PV	-PV	AUC
45	100	--	88.	0.500

Up to 78% of cases presented by acute appendicitis signs seen with US were matching to intraoperative findings, while 22% were not matching. About 70% of cases diagnosed as intestinal obstruction, signs seen with US were matching to intraoperative findings, while 30% were not matching. Only 16.6% of cases diagnosed as perforated viscus, signs seen with US were matching to intraoperative findings, while 83.3% were not matching (Table 5).

Table 5: Matching of US findings with that seen intra-operative.

Diagnosis	Total	Matching	No.	%
Acute appendicitis	25	**Matching**	19	78
		Not matching	6	22
Intestinal obstruction	**20**	**Matching**	14	70
		Not matching	6	30
Perforated viscus	**12**	**Matching**	2	16.6
		Not matching	10	83.3

Table 6 shows that almost all findings of CT were matching to the intraoperative data in the cases included in the study.

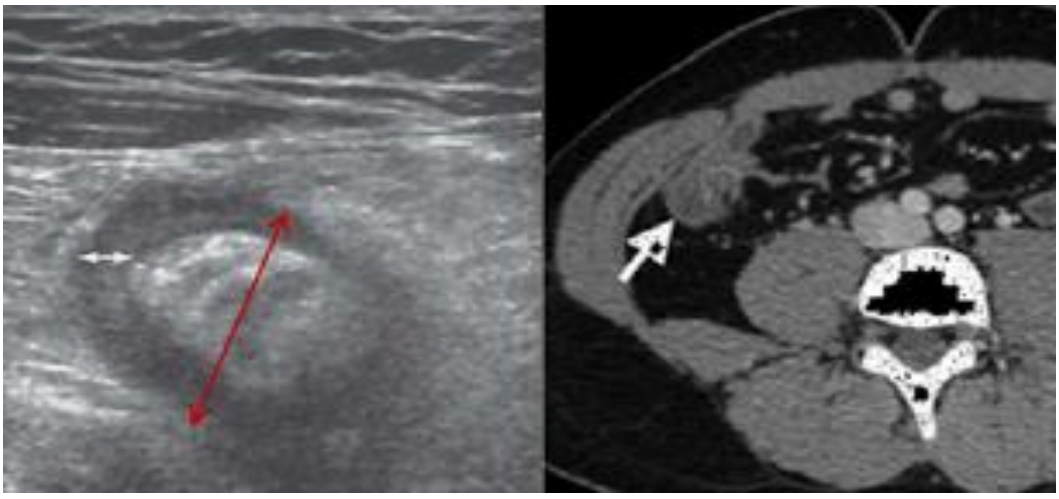
Table (6): Matching of CT findings with that seen intra-operative.

Diagnosis	Total	Matching	No.	%
Acute appendicitis	**25**	**Matching**	24	96
		Not matching	1	4
Intestinal obstruction	**20**	**Matching**	18	90
		Not matching	2	10
Perforated viscus	**12**	**Matching**	11	91.6
		Not matching	1	8.3

CASE 1

Acute appendicitis

A 11 years old boy presented to the emergency unit at Pediatric Hospital with acute onset of right iliac fossa pain of 2 hours duration referred to the right hip joint and right thigh a combined by fever and vomiting. Initial examination and investigations was done initial diagnosis was acute appendicitis.



Ultrasound findings: **Swollen appendix**

CT findings: **Swollen appendix.**

Diameter ≥7 mm, Outer wall to outer wall

CASE 2

Acute appendicitis.

A 14 years old boy presented to the emergency unit at pediatric hospital with mid abdominal region pain and later on shifted to right iliac fossa pain of 3 hours duration referred to the right flank and suprapubic pain a combined by anorexia and vomiting.

Initial examination and investigations was done initial diagnosis was acute appendicitis.

Ultrasound findings:
Thickened wall ≥ 3 mm

CT findings:
Thickened appendix

DISCUSSION

In this study, we aim to reach the correct full diagnostic data in the least possible time to allow good outcomes of the management lines, and this took place through comparing the accuracy of diagnosis between the most used imaging modalities which are abdominal ultrasound and MDCT.

In this study, 70 patients were included, with a mean age 9 years, less than18 years. About 59.3% were males and 40.7% were females.

The most frequent final diagnosis was acute appendicitis and its complications which show the highest percentage (37.5%) and intestinal obstruction which was 28.6%.

In this study, relying on US only in all of the included cases would have led to many false diagnosis's or in the best conditions may lead to incomplete diagnosis which the management plan cannot rely on, while in some other cases it gave a very clear diagnostic data which was very helpful in management. So, in our study we recommend a different imaging plan for every single presentation.

Depending on the statistical results which evaluate the specificity and sensitivity of US in comparison to the MDCT as a gold standard having both sensitivity and specificity 100% and this compared with intraoperative findings.

Regarding to the cases which were presented by symptoms suggesting acute appendicitis, in comparison of CT with sonography a blinded prospective study was carried out by **Poortman *et al*.[8].** The authors claimed that MDCT and graded compression sonography performed by imaging radiologists and general radiology staff members in a general community teaching hospital had a similar accuracy for the diagnosis of acute appendicitis, where the sensitivity of CT and sonography was 76% and 79%, respectively, and the specificity was 83% and 78%, respectively.

While in other study carried out previously by **Adrienne et al.** [9] the result of US sensitivity in detection of acutely inflamed appendix was 76% versus 94% of CT.

In another clinical review which was conducted by **Humes and Simpson** [10] the sensitivity of US in diagnosing acute appendicitis was 86% versus CT 94%, and the specificity of US 81% versus CT 95%. The same study, however, noted that two additional prospective studies that evaluated the use of CT showed

a reduction in the number of unnecessary admissions and appendectomies. More significantly, some authors highlighted the risk of unnecessary ionising radiation exposure brought on by an overuse of CT scans.

In our study, the sensitivity of US in detection and visualization of an acutely inflamed appendix was 91.49% versus 100% in CT. While the specificity of both was 100%, taking into consideration that our study was carried out in a shorter time, with less number of patients. While the sensitivity of US decreased to 83.33% in detection of a complicated appendicitis, with appendicular abscess or appendicular mass, also the sensitivity of US declined to 45 % in perforated appendix, as it was misdiagnosed as appendicular abscess or mass, while perforated appendix was visualized clearly with MSCT.

In a research carried out about imaging strategies for detection of urgent conditions in children with acute abdominal pain (diagnostic accuracy study) **Lameris et al.** [(11)] stated that a single imaging strategy, computed tomography is better overall than ultrasonography in detecting urgent conditions.

A conditional computed tomography strategy, with ultrasonography in all patients and computed tomography only after negative or inconclusive ultrasonography, gives the highest sensitivity for detecting urgent conditions with this conditional computed tomography strategy, only half of patients would require computed tomography.

This may resemble our study in complicated appendicitis as an urgent abdominal condition if a complicated appendicitis is suspected at any stage clinically or radio graphically this can be considered as the condition in which MDCT should be used as the ultrasound was proved to be not satisfactory in detecting or identifying the boundaries and the accurate size of the appendicular mass or abscess.

Because of its excellent diagnostic accuracy and usefulness for identifying periappendiceal inflammatory masses, CT is preferred in children who may have appendiceal perforation.

So in acutely inflamed appendix examination by conventional abdominal US can be satisfactory, while in long standing symptoms of acute appendicitis which is supposed to be complicated or perforated assessment with MSCT is kindly recommended, Also if the radiologist is diagnosing appendicular mass or abscess using US, further assessment with MSCT before treatment plan is recommended.

As it can provide more information regarding the size, boundaries and what is involved in the mass or the abcess, and is quite satisfactory in detecting a perforated appendix.

While the study by **Jaap Stoker et al. (2009**) [(12)] mentioned imaging patients with acute abdominal pain and stated that, for this indication, MDCT is currently taking the place of conventional radiography. This reflects the fact that multisection CT is more capable of detecting even minute amounts of free intraperitoneal air. Conventional radiography is only 33% sensitive for the detection of air pockets between 1 and 13 mm in size and is insensitive to air pockets smaller than 1 mm. The primary benefit of CT over radiography and US is that, in 86% of cases, it can accurately display the actual site of perforation. Extra luminal air bubble concentration, a focal bowel wall defect, and segmental bowel wall thickening are CT findings that are strongly linked to the accurate localization of a perforation. A helpful clue of the perforation site is where the free air is located. Free air is most likely a sign of a gastroduodenal perforation if it is found near the liver and stomach. Colon or appendix perforation is more common when free air is found, particularly in the pelvic, supramesocolic, and inframesocolic regions. Perforations can be seen using multiplanar reformations at CT.

When echogenic lines or spots with comet-tail reverberation artefacts are found close to the abdominal wall in a supine patient, a perforation can be identified using ultrasound technology. For the identification of perforation with US, a sensitivity of 92% and a specificity of 53% have been recorded, adding up to an overall accuracy of 88%. It is significant to highlight that with US, determining the origin and location of the perforation is challenging [(5)].

In our study, only 12 cases were included who presented with perforated viscus, The US was satisfactory in detection of free intraperitonal collection, but not able to reach the diagnosis only in 16.6% of cases of perforated viscus, Only MSCT, or X-ray was able to suspect the diagnosis on the presence of free intraperitoneal gas, or gas under the diaphragm, in absence of recent operative history. So when the diagnosis of perforated viscus is suspected, MSCT is highly recommended.

A study which was carried out by Adrienne **van randen et al.** [(9)] about a comparison of the accuracy of US and CT in common diagnosis's causing acute abdomen; stated that accuracy of acute cholecystitis were not significantly different.

Regarding localized intra-abdominal infection, a previous study carried out by **Hagaa** (1990) [(13)] named imaging intraabdominal abcesses and non-operative drainage procedures: stated that, US sensitivity was 82% versus CT 97.5%, and US specificity was 94.5% versus CT 85% [(14)].

Two cases with localized abscesses were included in our study, one of them were diagnosed by US, and not only diagnosed, but also US was helpful in aspiration of the inflammatory fluid, but the other one was mis diagnosed. So on cases presented with: fever with acute abdomen, with no obvious reason on clinical or ultrasonographic examination, MSCT is highly recommended. In the current study the specificity in both US and MDCT was 100%. So it is worthy to mention that all of the previously mentioned studies

were carried out in more time with more children included and this explained there was some difference in the results. Also some of them were repeated where more expert radiologists were examining the children and the sensitivity of the US and CT was better and it was attributed to the experience of the operator. In Assiut University Hospital where the current study was carried out well trained residents examined the cases and in many times the cases were re-examined by more senior radiologists.

CONCLUSION

Only 3% of the participants in this study had non-diagnostic ultrasonography or a diagnostic dilemma. Although CT provides a diagnostic advantage over ultrasound, particularly in surgical instances, it should only be used in cases where the diagnosis is truly challenging due to radiation exposure risks. When acute appendicitis is suspected, the possibility of complicated appendicitis as in appendicular mass or abcess, or a perforated appendix should be excluded during the sonographic examination, otherwise plain MDCT is recommended. In cases presented with fever and acute abdomen a good sonographic search for localized inflammatory reaction is recommended if it is negative or inconclusive, CT with contrast is recommended.

DECLARATIONS

- **Consent for Publication:** I confirm that all authors accept the manuscript for submission
- **Availability of data and material:** Available
- **Competing interests:** None
- **Funding:** No fund
- **Conflicts of Interest:** The authors declare no conflicts of interest regarding the publication of this paper.

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