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The Role of Ultrasound and CT in Diagnosis of Acute Appendicitis & Its Impact on The Surgical Outcome

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ABSTRACT

Background: The emergency room's most dependable and accessible diagnostic imaging tools for detecting appendicitis early and averting catastrophic complications by ultrasound (US) computed tomography (CT) imaging.

Objective: To evaluate the role of ultrasound and CT in the diagnosis of acute appendicitis and their impact on surgical outcomes.

Patients and Methods: This study was carried out as a prospective cross-sectional in collaboration between Surgery and Radiology Departments, Faculty of Medicine, Cairo University, Cairo, Egypt. We included 45 patients who were presented by symptoms of acute appendicitis, examined by pelvi-abdominal US then contract enhanced CT. The results of both Ultrasound and CT were correlated with the surgical outcome aiming of the study for diagnosis of acute appendicitis.

Results: A total of 45 patients were included in the final analysis of our cohort research. The average age of the patients was 25 years with a standard deviation of 9 years. Males represented 53.3% while females represented 46.7% of the included patients. Our analysis revealed that CT exhibited a higher sensitivity than US if we used a cutoff point 2 findings by CT 100% versus 60.4% in US, while both were equal in specificity 85.7% in both modalities. CT and US can significantly predict positive surgical outcome.

Conclusion: Detection of acute appendicitis by Ultrasound and CT were prior to any surgical intervention, reduces the negative appendectomy rate and the complications that may occur due to either improper diagnosis or unnecessary intervention.

Keywords: Ultrasonography, Computed tomography, Appendicitis, Surgical intervention.

INTRODUCTION

With an annual incidence of about 1 per 1000 persons and a lifetime risk of 7 to 9 percent in developed countries, acute appendicitis is a prevalent cause of abdominal discomfort. Appendicitis is the term for the inflammation of the vermiform appendix; nevertheless, the aetiology and progression of the condition remain unclear. A tumor blocking the appendix lumen can cause appendicitis, as can fecoliths, or caecum obstructions, but it also appears that genetic and environmental factors play a role in the development of appendicitis [(1)].

The most typical first symptom is central abdominal discomfort; other symptoms include anorexia, nausea, vomiting, and pain migration to the right iliac fossa. The most effective treatments for acute appendicitis are early detection and surgical intervention [(1)].

A delayed diagnosis of appendicitis can result in significant consequences, such as pylephlebitis, an infective thrombophlebitis of the portal circulation, and perforation leading to widespread peritonitis, which is regarded as a dangerous and deadly disease. Consequently, the necessity of imaging diagnostic tests is significant. The emergency room's most dependable and accessible diagnostic imaging tools for detecting appendicitis early and averting catastrophic complications are ultrasound and CT imaging. Due to its ease of use, lack of radiation exposure, and relatively low cost although still operator-dependent, ultrasound is currently regarded as the first line of diagnostic imaging for any abdominal emergency [(2)].

A normal appendix is removed during a negative appendectomy, a surgical problem. Patients are put at risk for needless hospital expenses, anesthesia, and surgical side effects include wound infection, bleeding, damage to surrounding organs, and intestinal blockage [(3)].

With growing ultrasound and CT (computed tomography) technology knowledge and accessibility, In order to reduce the complications of appendicitis and the percentage of unsuccessful appendicectomy, there are now additional diagnostic tools accessible to the treating physician for monitoring patients with a suspicion of acute appendicitis before any surgical intervention [(3)].

AIM OF THE STUDY

This study's goal is to evaluate of the role of ultrasound and computed tomography (CT) in the diagnosis of acute appendicitis and their impact on surgical outcomes.

PATIENTS AND METHODS

Forty-five cases with suspected acute appendicitis were admitted to the Trauma and Surgical Emergency Unit of Kasr El-Aini Hospital, Faculty of Medicine, Cairo University, Cairo, Egypt, in the period

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from May to October, 2021. Some of those patients had typical clinical presentation of acute appendicitis. Patients of different sex and different age groups were selected.

Those patients we supposed that they may gain benefit of early diagnosis of acute appendicitis by using the ultrasonography graded compression, so that proper and early management can be achieved to reduce the high risk of late or misdiagnosis of acute appendicitis. Those patients included 24 males and 21females. Their age ranged from 16-35 years old.

The patients were subjected to full history taking, thorough clinical examination and laboratory investigations especially total leucocytic count.

All studied groups underwent the following:

1- History taking: Full history was collected as occupation as well as family history.

2- Clinical examination: General examinations, vital signs.

3- Laboratory investigations: Complete blood count. Prothrombin time, prothrombin concentration, & INR, AST, ALT, serum bilirubin, and albumin. Viral markers HBs Ag, HCV Ab and PCR of HCV.

4- Imaging procedures:

A- Ultrasonography of abdomen and pelvis:

To visualize the appendix. Transverse scanning was used to start the examination at the umbilical level, and it was then continued caudally with gradual compression over the right lower quadrant to compress the bowel loops and displace the air, allowing visualization of the retroperitoneal structures such as the iliopsoas muscle and iliac vessels, which were used as landmarks in the exploration of the appendix area. If an appendix was evident and its wall thickness measured 6 mm or more, or if a periappendiceal mass or abscess was found, the ultrasonographic results were considered positive.

Near the caecum, an inflamed appendix was seen as a tubular structure with an echo-poor lumen and layers that were both inner and exterior. It had a base pointing toward the caecum and a blind end (tip). It was not compressible and lacked peristalsis. A 3.5 MHz transducer was used to do real-time sonography scanning of the whole abdomen and pelvis in all patients to look for other illnesses or possible diagnoses.

B. Computed Tomography:

All patients had intravenous contrast-enhanced abdominopelvic CT utilising omnipaque 300. During the portal venous phase, the belly and pelvis were scanned to check for appendicitis and injected by mechanical injector at a rate of 3ml/sec. All contrast-enhanced scans were performed helically by GE Healthcare utilizing 3 mm thick continuously reconstructed pictures, from the top of the diaphragm to the lesser trochanters.

Acute appendicitis was diagnosed in patients with the following CT findings: a swollen appendix measuring more than 6 mm, mucosal enhancement, peri appendiceal fat stranding, or free fluid in the right iliac fossa. The outcomes of the ultrasound and CT scans were connected to the success of the surgery, which was the goal of the study to diagnose acute appendicitis.

Ethical consent:

This study was ethically approved by the Institutional Review Board of the Faculty of Medicine, Cairo University. Written informed consent was taken from all participants. The study was conducted according to the Declaration of Helsinki.

Statistical analysis:

Version 22 of the IBM SPSS application was utilized. In order to determine the significance of the acquired results, a 5-percent threshold was used. It was a Chi-square test. For categorical variables, Chi-square correction for more than 20% of cells with anticipated count less than 5 was required, student t-test: to calculate the quantities of data of normal distribution and to compare between two studied groups.

RESULTS

A total of 45 patients were included in our final analysis, all patients were presented in to Emergency Department of Kasr Alainy Teaching hospital with symptoms suggesting acute appendicitis. They had a mean age 25 ± SD 9 years old, males had a slight predominance 53.3%.

Table (1): Demographics.

		Count	Column N %
Age (mean ± SD) years		25	9
Gender	Male	24	53.3%
	Female	21	46.7%

Among the included patients only 7 patients (15.6%) had negative surgical outcomes, while 84.4% had positive surgical outcomes. **(Table 2)**

Table (2): Surgical outcomes.

		Count	**Column N %**
Surgical Outcome	**Negative**	**7**	**15.6%**
	Positive	**38**	**84.4%**

There was a statistically significant difference among number of US findings between patients with positive and negative surgical outcome with p value 0.004, this difference was even higher in CT findings with p value 0.0001. **(Table 3)**

Table (3): Comparison of physical examination based on surgical outcome.

	Surgical Outcome				P value
	Negative		Positive		
	Mean	Standard Deviation	Mean	Standard Deviation	
Pulse	87	3	95	12	0.06
MPB	41	4	43	9	0.63
Temperature	37.5	0.4	37.8	0.5	0.22
TLC	14.99	3.74	13.68	3.39	0.48
Number of positive findings by US	0.4	0.1	2.1	0.3	0.004
Number of positive findings by CT	0.7	0.11	3.8	0.8	0.0001

US findings showed various sensitivity in detecting positive surgical outcome, as distend appendix in US had a sensitivity 95% and specificity 24%. Periappendiceal fluid collection had a sensitivity 96.9% in detecting positive surgical outcome, also Echogenic Fat had a sensitivity 0.001, and detected 100% of the complications of acute appendicitis. Significant difference was reported between surgical outcomes in terms of distended appendix p value 0.0001, echogenic fat 0.001, and incidence complications 0.0001. **(Table 4)**

Table (4): Comparison of ultrasound findings based on surgical outcome.

		Surgical Outcome				P value
		Negative		Positive		
		Count	Row N %	Count	Row N %	
Distended appendix	No	6	24.0%	19	76.0%	0.0001
	Yes	1	5.0%	19	95.0%	
Periappendiceal fluid collection	No	6	46.2%	7	53.8%	0.07
	Yes	1	3.1%	31	96.9%	
Echogenic fat	No	6	28.6%	15	71.4%	0.001
	Yes	1	4.2%	23	95.8%	
Complications (Perforation or abscess formation) US	No	7	17.5%	33	82.5%	0.0001
	Yes	0	0.0%	5	100.0%	

CT findings as Appendiceal dilatation has a sensitivity 97.4% in detecting positive surgical outcome, while Appendicolith showed sensitivity 96.8%, Periappendiceal fluid collection 97.2%, Smudging of fat planes 94.9%, and presence of compilations 100%. Significant difference was reported between positive and negative surgical outcome in terms of Appendicolith was significantly higher among positive groups, and complications as performation or abscess formation with p values 0.039 and 0.0001 respectively. **(Table 5)**

Table (5): Comparison of CT findings based on surgical outcome.

		Surgical Outcome				P value
		Negative		Positive		
		Count	Row N %	Count	Row N %	
Appendiceal dilatation	No	6	85.7%	1	14.3%	1.0
	Yes	1	2.6%	37	97.4%	
Appendicolith	No	6	42.9%	8	57.1%	0.039
	Yes	1	3.2%	30	96.8%	
Periappendiceal fluid collection	No	6	66.7%	3	33.3%	0.62
	Yes	1	2.8%	35	97.2%	
Smudging of fat planes	No	5	83.3%	1	16.7%	1.0
	Yes	2	5.1%	37	94.9%	
Complications(Perforation or Abscess formation) CT	No	7	17.9%	32	82.1%	0.0001
	Yes	0	0.0%	6	100.0%	

Paired comparison of US and CT findings showed that there was a statistically signficant difference between US and CT in detecting Periappendiceal fluid collection which was higher using CT p value 0.0001, as well as, presence of complications of acute appendicitis which significantly higher in CT findings with p value 0.0001. There was concordance between US and CT in detecting distended appendix and Echogenic fat/ smudging of fat planes. **(Table 6)**

Table (6): Paired comparison between CT and US findings.

		US		CT		P value
		Count	Column N %	Count	Column N %	
Distended appendix/ dilated appendix	No	25	55.6%	7	15.6%	1.0
	Yes	20	44.4%	38	84.4%	
Periappendiceal fluid collection	No	13	28.9%	9	20.0%	0.0001
	Yes	32	71.1%	36	80.0%	
Echogenic fat/ smudging of fat planes	No	21	46.7%	6	13.3%	0.12
	Yes	24	53.3%	39	86.7%	
Complications(Perforation or abscess formation) US	No	40	88.9%	39	86.7%	0.0001
	Yes	5	11.1%	6	13.3%	

Paired comparison of number of findings between US and CT revealed significantly higher mean number of findings in CT examination with p value 0.0001 **(Figure 1).**

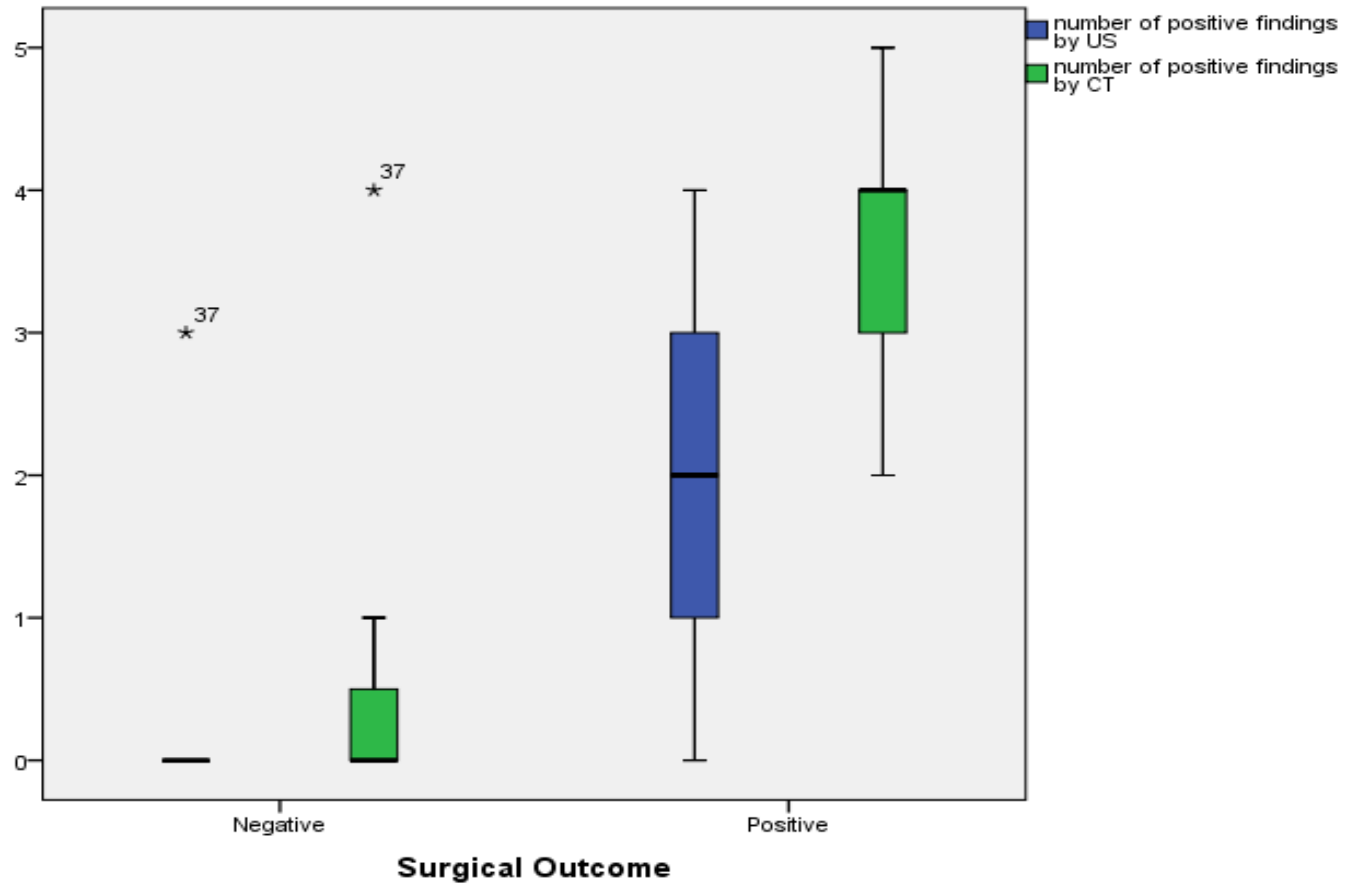

Figure (1): Box plot showing difference in the number of CT and US findings based on surgical outcomes.

Sensitivity analysis revealed that CT had a higher sensitivity than US if we used a cutoff point 2 findings by CT 100% versus 60.4% in US, while both were equal in specificity 85.7% in both modalities. CT and US can significantly predict positive surgical outcome with p values 0.006 and 0.0001, AUC 83% and 92% respectively. **(Table 7)**

Table (7): Sensitivity analysis of CT and Ultrasound findings.

Test Result Variable(s)	AUC	Std. Error	P value	Cutoff	Sensitivity	Specificity	95% Confidence Interval	
US	0.83	0.092	0.006	2 positive finding	60.5%	85.7%	0.653	1.000
CT	0.92	0.078	0.0001	2 positive findings	100%	85.7%	0.768	1.000

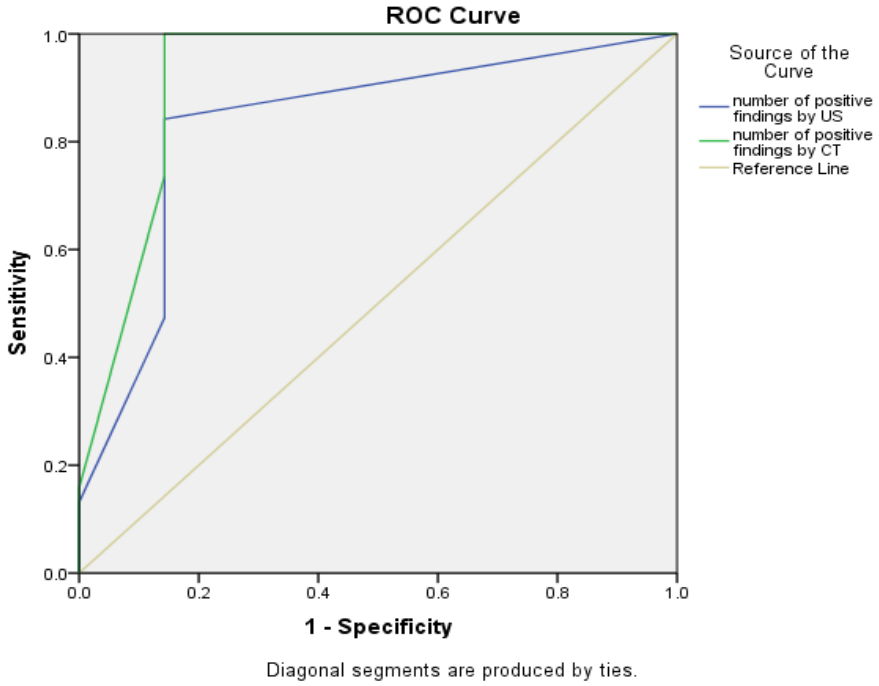

Figure (2): ROC curve showing the predictability of imaging modalities to positive surgical findings.

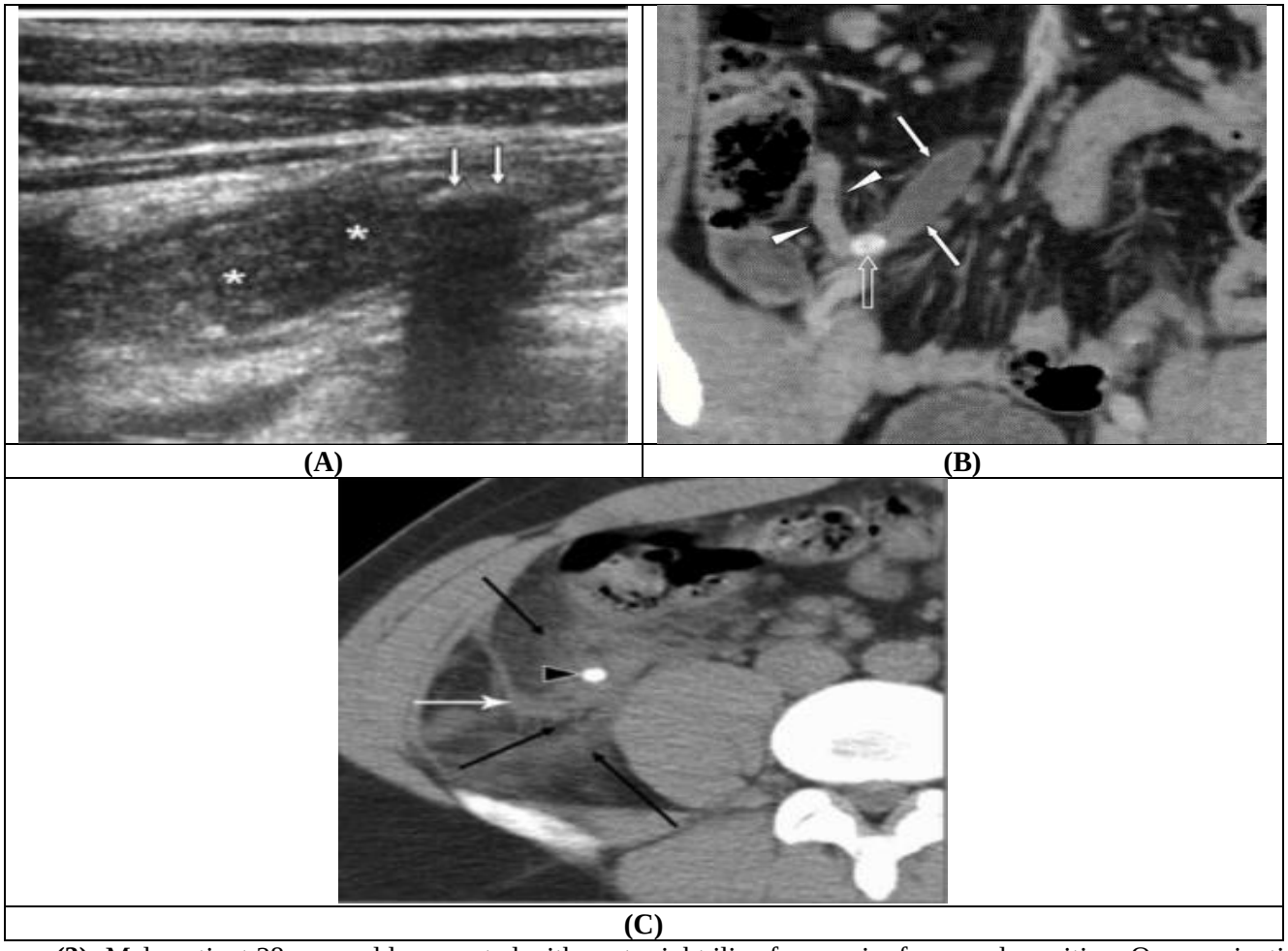

Figure (3): Male patient 28 years old, presented with acute right iliac fossa pain, fever and vomiting. On examination, tenderness and rebound tenderness at the right iliac fossa, leucocytosis. Alvarado score 9. Diagnosis confirmed by surgical exploration. Abdominal Ultrasonography Reveals: **A.** dilated appendix (star) containing appendicolith(arrow). MSCT**: B,C**. Coronal reformatted and axial mages clearly showing the full appendix, with an appendicolith (open arrow in coronal image and black arrow head in axial image) between the collapsed proximal portion (arrowheads) and the inflamed distended distal portion(solid arrows) with smudging of periappendiceal fat planes(black arrows).

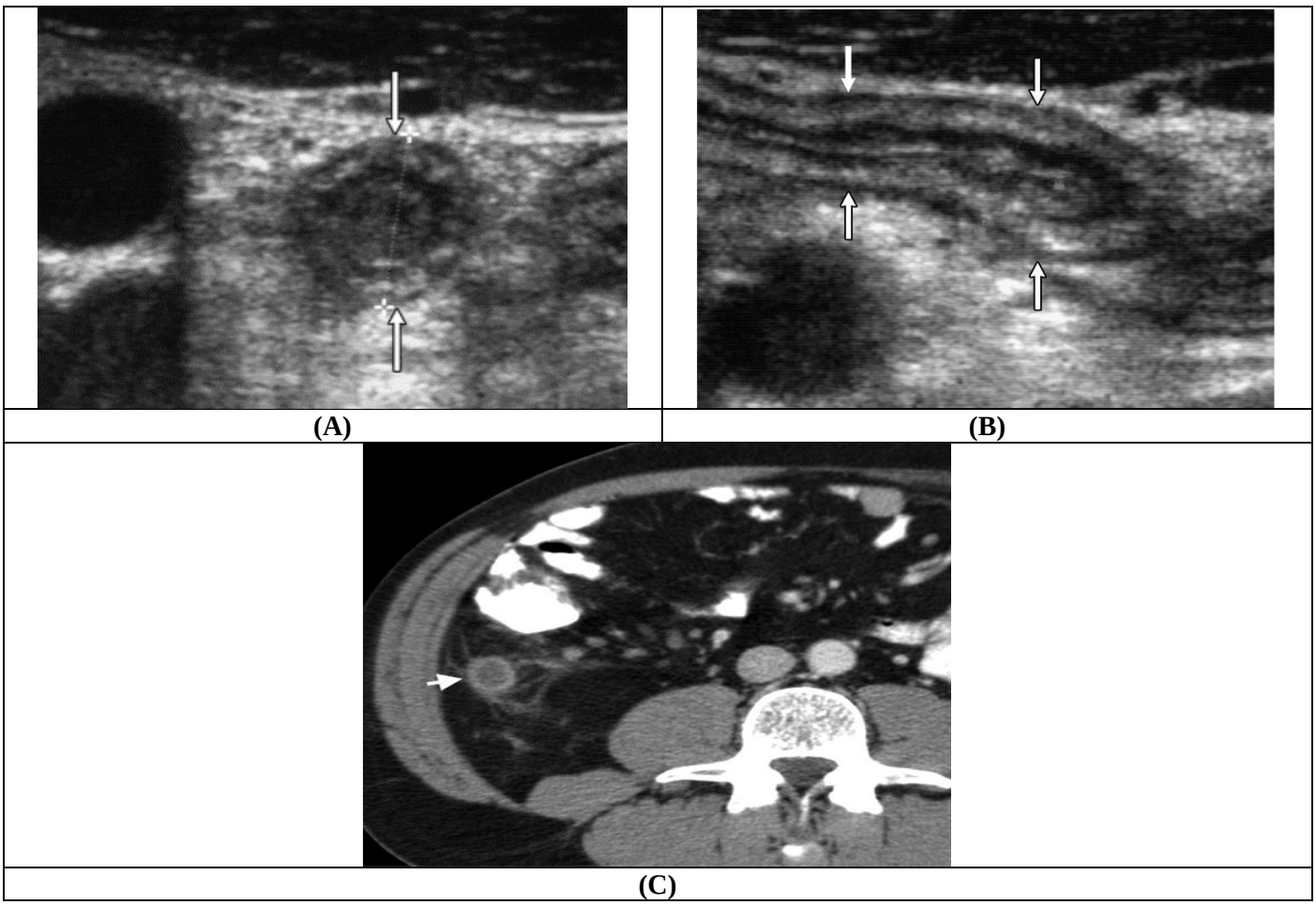

Figure (4): Male patient 35 years old, Acute Right iliac fossa pain with vomiting , tenderness and rebound tenderness of right iliac fossa and leukocytosis diagnosed as acute appendicitis. Alvarado score 9. Diagnosis confirmed by surgical exploration. Abdominal ultrasonography transverse and longitudinal abdominal scanning Reveals: Thickened appendicular wall, and increased its diameter of 9.2 mm. (arrows). MSCT: Transverse contrast-enhanced CT scan showing a distended appendix with a diameter of 10 mm.

DISCUSSION

The conventional procedure for diagnosing appendicitis includes imaging. Computed tomography and ultrasound imaging are the two most popular imaging methods (CT) [(4)]. On the basis of radiological evidence, an accurate diagnosis of acute appendicitis can be made [(5)].

Conflicting data exist in Egypt on the use of ultrasound vs CT scan with contrast in the evaluation of patients of acute appendicitis in emergency settings [(6)]. In order to assess the function of ultrasound and computed tomography in the diagnosis of acute appendicitis and its impact on the surgical outcome, we undertook a prospective cross section research.

Epidemiological studies showed that peak incidence of acute appendicitis had been reported among children with age 13 years till 25 years with slightly higher incidence in males of the same age categories [(7, 8)]. These findings were similar to the reported demographics of the included patients in the current work.

In the present study, positive ultrasound findings included, distended appendix in 44.4%, Peri-appendiceal fluid collection 71.1%, Echogenic fat in 53.3% and suspected Complications (as Perforation or abscess formation) 11.1%. Mean number of positive findings were 1.8 ± SD 1.4 signs. CT findings showed that Appendiceal dilatation was reported in 84.4%, Appendicolith in 68.9%, Periappendiceal fluid collection in 80%, Smudging of fat planes in 86.7%, as Complications (Perforation or Abscess formation) in 13.3%. Mean Number of positive findings by CT among include patients was 3.3 ± SD 1.5 signs.

Among the included patients only 7 patients (15.6%) had negative surgical outcomes, while 84.4% had positive surgical outcomes. There was a statistically significant difference among number of US findings between patients with positive and negative surgical outcome with p value 0.004, this difference was even higher in CT findings with p value 0.0001.

These findings were consistent with the study conducted by **Al Ajerami** [(9)] when He reported a sensitivity of US in detecting acute appendicitis compared to surgical outcomes, a false positive rate of 4.4 percent, which is lower than the one reported in the present work, as well as an overall sensitivity 84.8

percent and specificity 83.3 percent of the US. However, these findings varied depending on gender as the false positive results were significantly higher among femal patients[9].

In the present study, US findings showed various sensitivity in detecting positive surgical outcome, as distend appendix in US had a sensitivity 95% and specificity 24%. Periappendiceal fluid collection had a sensitivity 96.9% in detecting positive surgical outcome, while Echogenic Fat had a sensitivity 100%, and detected 100% of the complications of acute appendicitis.

These findings are consistent with other studies in literature that reported real time ultrasound findings are categorized into direct signs and indirect ones, they highlighted distended appendix >6 mm is considered a diagnostic sign for acute appendicitis [10, 11].

On contrast, many studies had identified increased echogenicity of the adjacent periappendiceal fat[12], and Periappendiceal fluid collection as secondary signs that support the diagnosis of acute appendicitis [13].

In the current study, CT findings as Appendiceal dilatation has a sensitivity 97.4% in detecting positive surgical outcome, while Appendicolith showed sensitivity 96.8%, Periappendiceal fluid collection 97.2%, Smudging of fat planes 94.9%, and presence of compilations 100%.

These results are in accordance with **Sim *et al.*** [14] who included 294 patients with acute appendicitis who underwent US and CT assessment. Results showed that increased appendix dilatation had a sensitivity of 99.3 percent, smudging of fat planes around the appendix had a sensitivity of 93.2 percent when compared with operative findings, but periappendiceal fluid collection showed a low sensitivity of 17.9 percent, which was irrational.

In the present work, paired comparison of US and CT findings showed that there was a statistically significant difference between US and CT in detecting Periappendiceal fluid collection, which was higher using CT p value 0.0001,

These results are in line with a sizable prospective cross-sectional study that examined 1021 patients with acute abdominal pain. The results showed that CT had a significantly higher sensitivity for detecting appendicitis than ultrasound, at 94 percent versus 76 percent (p 0.01), and that positive predictive values did not differ significantly between the two modalities [15].

83 percent sensitivity and 93 percent specificity for ultrasound were shown to be superior than 94 percent sensitivity and 94 percent specificity for CT in a major meta-analysis comparing the use of ultrasound against CT in the diagnosis of acute appendicitis [16].

In the present study, detection of complications of acute appendicitis was significantly higher in CT findings with p value 0.0001. these findings was consistent with a large meta-analysis which showed that CT can detect complicated appendicitis more accurately compared to ultrasound with p value <0.01 [17, 18].

In the current study, sensitivity analysis revealed that CT had a higher sensitivity than US if we used a cutoff point 2 findings by CT 100% versus 60.4% in US, while both were equal in specificity 85.7% in both modalities. CT and US can significantly predict positive surgical outcome with p values 0.006 and 0.0001, AUC 83% and 92% respectively.

These results are in line with those of a study by **Sim *et al.*** [14] who found that CT scans had a 100% sensitivity for acute appendicitis detection, a 98% specificity, and a 95% overall diagnostic accuracy. They also found that combining US and CT scans for diagnosis had a 100% sensitivity, a 98% specificity, and a 99.2% overall diagnostic accuracy.

CONCLUSION

CT and ultrasound are both sensitive diagnostic tools for diagnosis of acute appendicitis, however CT scan provide a more accurate results in terms of detection Periappendiceal fluid collection, and presence of complicated appendicitis. CT demonstrated significantly higher sensitivity compared to US in diagnosis of acute appendicitis when using 2 findings as a cut of number of findings. CT can be used as a complementary imaging modality or as an initial one for diagnosis of acute appendicitis in emergency settings.

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