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Assessment of the value and findings of CT in diagnosing acute appendicitis

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Abstract: Appendicitis is one of the most common abdominal emergencies. Patients are usually presented with lower right abdominal pain, nausea, vomiting and fever. Acute appendicitis is a challenging clinical diagnosis, and patients with suspected appendicitis can be diagnosed by Ultrasound (US) or computed tomography (CT) according to the hospital protocol and patient clinical condition. The aim of this study is to investigate the value of CT in diagnosing suspected cases of acute appendicitis. Retrospective research to evaluate the role of CT scan in the diagnosis of acute appendicitis, based on data received from King Abdulaziz university hospital in Jeddah, from January 2017 to January 2022. A total of 204 patients (121 Males and 83 Females) ranging in age from 2 to 91 years presented with acute appendicitis were included. The collected data included age, gender, patients' complaints, medical history, laboratory tests, radiology reports, operations, and pathological results. The most prevalent age group was 10-30 years old. Most patients (77%) presented with typical appendicular pain, while (56%) presented with vomiting. CT was requested for 142 patients while 35 patients were referred to Ultrasound. Both modalities were done to 27 patients. The Commonest finding in CT scan was dilated appendix with sensitivity of 84% with 100% overall diagnostic sensitivity. CT is a sensitive tool used to diagnose acute appendicitis and its complications. It is recommended to be used as the primary imaging modality in cases of acute appendicitis.

Keywords: *Acute appendicitis, CT scan, Imaging findings, Right lower iliac pain, Ultrasound.*

1. Introduction

Acute appendicitis is the most common cause of abdominal emergency surgeries with an incidence of 90–100 per 100,000 population [1] and the lifetime prevalence of appendicitis is approximately 7 % [2]. Also, appendicitis affects roughly 250,000 people each year in the USA [3].

Ultrasonography and computed tomography (CT) can help diagnosing patients with suspected appendicitis. When a diagnosis is equivocal based on history and physical examination, Ultrasonography is utilized. But due to the overlap of symptoms of acute appendicitis with other causes of acute abdominal pain that don't need urgent surgical intervention such as Crohn's disease and lot of abdominal and pelvic inflammatory processes, CT scan becomes a more useful tool to reach definitive diagnosis of appendicitis. CT is also of great importance in detecting complications of appendicitis which may occur due to delayed diagnosis and treatment [4].

Appendicitis usually develops acutely within 24 hours of onset, but it can also manifest as a chronic condition. Classically, appendicitis first presents with diffuse or periumbilical abdominal pain that lasts for hours then spreads to the right iliac fossa. It is usually accompanied by a lack of appetite, nausea, or vomiting. Atypical histories may begin with just discomfort in the right lower quadrant [5].
Delayed diagnosis may lead to rupture and widespread peritonitis or abscess formation [6].

Patients with suspected appendicitis benefit from ultrasonography and computed tomography studies. Ultrasonography is utilized when a diagnosis is ambiguous based on the patient's medical history and physical examination. It is primarily used in female and pediatric patients with right lower quadrant or pelvic pain [7].

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To rule out appendicitis, a normal appendix (6 mm or smaller in diameter) must be found. An inflamed appendix is often larger than 6 mm in diameter, non-compressible with focal and rebound tenderness. Irritable bowel syndrome, cecal diverticulitis, Meckel's diverticulum, endometriosis, and pelvic inflammatory disease are just a few of the conditions that can cause false-positive Ultrasound results in the right lower quadrant [4, 9].

CT examination is increasingly recommended for all patients with suspected acute appendicitis [10]. Accurate diagnosis of appendicitis is crucial because laparoscopic appendectomy is extensively used for uncomplicated cases, while laparotomy is the rule for critically ill patients presenting with complications [11]. The use of helical CT in patients with suspected appendicitis improves patient outcomes and the number of successful laparotomies [3].

Getting a diagnosis is especially challenging for infants, small children, elderly patients, and women of reproductive age where Ultrasound will be of choice. For CT, the amount of intraperitoneal fat, the sufficient demonstration of terminal ileal loops and cecum, the form and quality of examination, and the clinical experience all play a role in visualisation of the appendix.

CT criteria of acute appendicitis include a diameter greater than 6mm, peri appendiceal inflammation of the mesenteric fat, appendicolith, circumferential mural thickening with homogeneous dense contrast enhancement and target sign seen on axial images.

2. Patients and Methods

collecting data belong to 204 (83 Females and 121 Males) ranging in age from 2 years to 91 years, with the mean age 27 years ± 17, who were diagnosed with acute appendicitis. All patients presented to the emergency department with acute abdominal pain with positive tenderness in the right iliac fossa denoting clinically suspected appendicitis. Depending on the physical examination and the patient condition, 142 patients were referred to CT scan only, and 35 of patients were referred to Ultrasound only. However, 24 patients were imaged by Ultrasound followed by CT scan, while only 3 patients were imaged by CT scan followed by Ultrasound.

3. Patients and Methods

This is a retrospective study based on data received from the phoenix system of King Abdulaziz university hospital, Jeddah between January 2017 to January 2022. Ethical approval was obtained from the ethical committee of the faculty of medicine. The collected data included age, gender, patients complain, medical history, laboratory tests, radiology reports, and surgical results.

Radiological examinations were done by using x-ray (Kodak), Ultrasound (Philips EPIQ 7, Philips iU22, Philips - HD11), and computed tomography (Siemens128 dual source and 64 single source). CT examinations were performed using intravenous and oral Urografin contrast media. Standard CT abdomen- pelvis protocol was typically done for all patients.

4. Statistical Analysis

Patients' data were retrieved from hospital records in Microsoft excel format. Data were transformed into SPSS format using IBM SPSS Statistics for Windows, Version 25.0. Armonk, NY: IBM Corp.

Description of categorical data was presented by number and percentage. Demographic features (age, gender), referring department, clinical features and imaging's findings were described. Sensitivity of each of CT findings are calculated as follows (number of positive finding/total patients underwent CT) as all patients were diagnosed with appendicitis. Specificity was not calculated as no patients with normal appendix were enrolled in this study.

Based on the commonest age group affected by appendicitis, patients were categorized into 3 groups by age: <10 years, 10-30 years and >30 years old groups. An assessment of the relationship between the number of positive findings and age group was conducted by Chi-square test.

P value was considered significant if less than 0.05.

Results:

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The study included 204 patients with suspected appendicitis. Appendicitis diagnosis was confirmed later either surgically or medically. Male patients were more than female patients (59% and 41% respectively). Patients were classified according to their ages into 3 groups. The most prevalent age group was from 10-30 years old. Table (1) shows demographic data of participants.

Table 1.
Demographic features of participants.

		Frequency	Percent
Gender	F	83	40.7
	M	121	59.3
Department	ER	194	95.1
	Inpatient	10	4.9
Age groups	<10	19	9%
	10-30 yrs	119	58%
	>30 yrs	66	32%
Age	Mean		26.9
	Median		23.0
	Std. deviation		16.5
	Minimum		2.0
	Maximum		133.0
	Percentiles	25	16
		50	23
		75	33

Most of patients (77%) presented with typical right lower quadrant appendicular pain, and 56% presented with associated vomiting. Other clinical manifestations are shown in Table 2.

Table 2.
Clinical features of patients.

	Frequency	Percent
Typical appendicitis pain	157	77.0
Vomiting	115	56.4
Nausea	71	34.8
Fever	63	30.9
Rebound Tenderness	61	29.9
RIF pain only	45	22.1
Diarrhoea	29	14.2
Unspecified pain	12	5.9
Constipation	12	5.9
Leucocytosis	133	65%

5. Imaging Findings

Plain abdominal X ray was initially performed to 23 patients with atypical pain to exclude other causes e.g. intestinal obstruction or volvulus. CT was done for a total of 168 patients; either as the first imaging modality or in patients with failed or equivocal US examination, while 62 were referred to US imaging as the primary imaging or after CT as shown in Table (3). Many cases were referred to US as the first imaging modality because of either being children or pregnant ladies.

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Table 3.
Imaging referral to radiology department.

		Frequency	Percent
Xray (n=24)	Primary	23	95.8
	Secondary	1	4.2
US (n=62)	Primary	57	91.9
	Secondary	5	8.1
CT (n=168)	Primary	124	73.8
	Secondary	43	25.6
	Tertiary	1	0.6

The most sensitive finding in CT imaging was dilated distended appendix more than 7 mm (sensitivity 84%) and thickened wall more than 3 mm (60%) associated with inflammation of the adjacent fat (Figure 1).

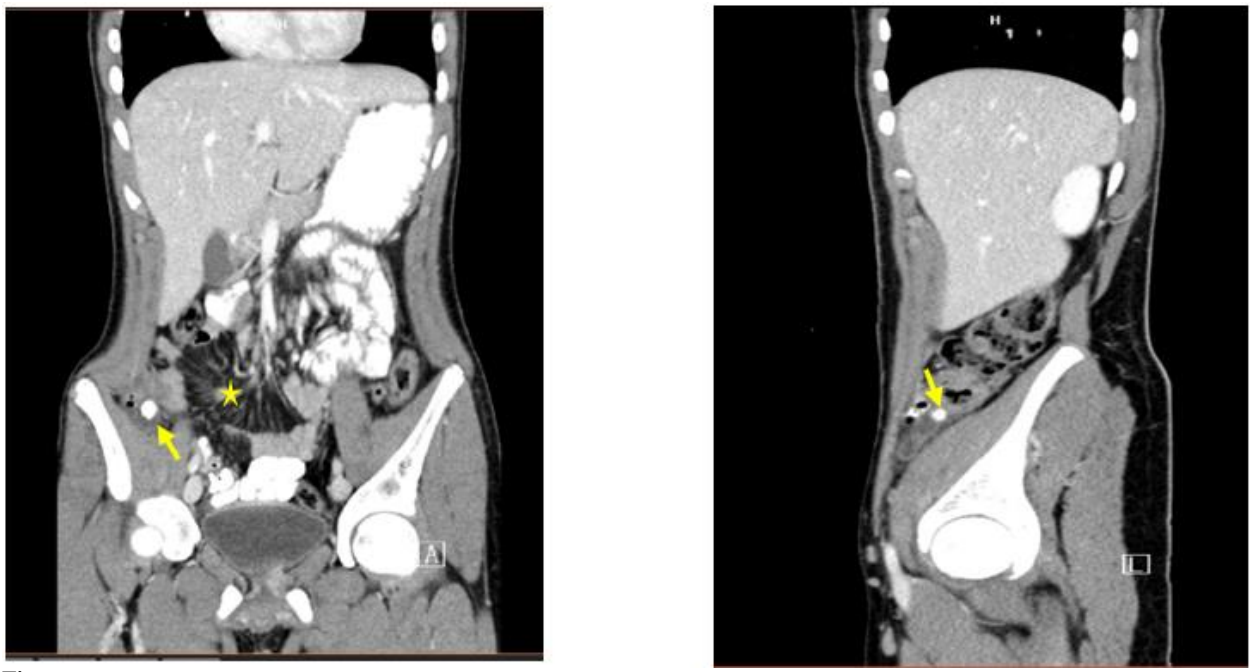

Figure 1.
14 y/o male, presented with right lower quadrant abdominal pain and vomiting with high white blood cells (WBC). CT showed dilated appendix measuring 1.6 cm in diameter, associated with surrounding fat standing (star) along with 1 cm appendicolith within the appendix (arrow), also small surrounding lymph nodes are seen.

CT could detect associated appendicolith as well as complications such as perforation (12.9%) and abscess formation in 3% of patients. Details of CT findings are shown in figure 2.

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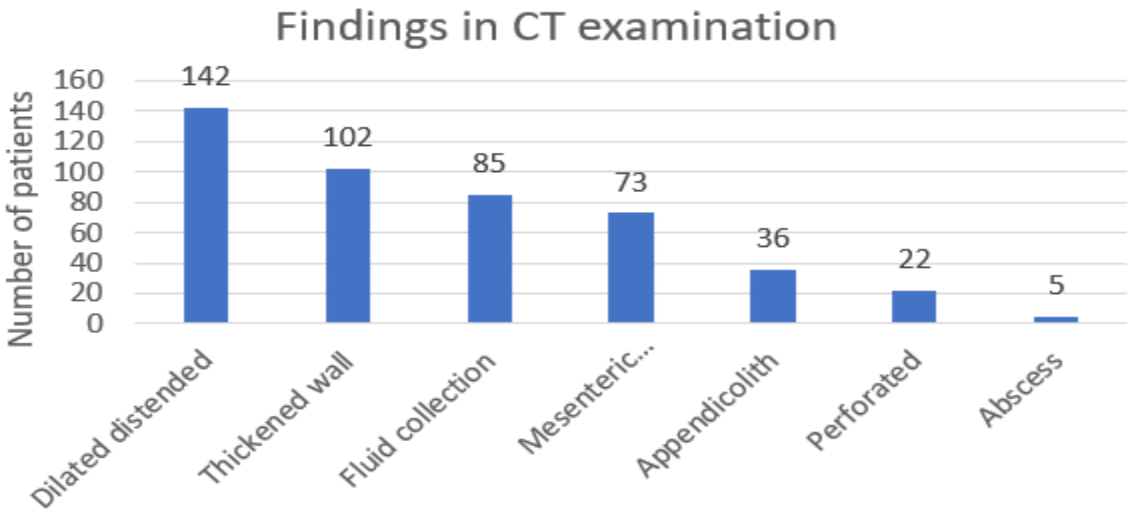

Figure 2.
Showing findings of CT examination.

US examination was limited in 27% of the patients due to marked gaseous distension and unprepared colon. Those patients were referred to CT. However, the commonest US finding is dilated appendix (23%) and the least was appendicular abscess (1%) (figure 3).

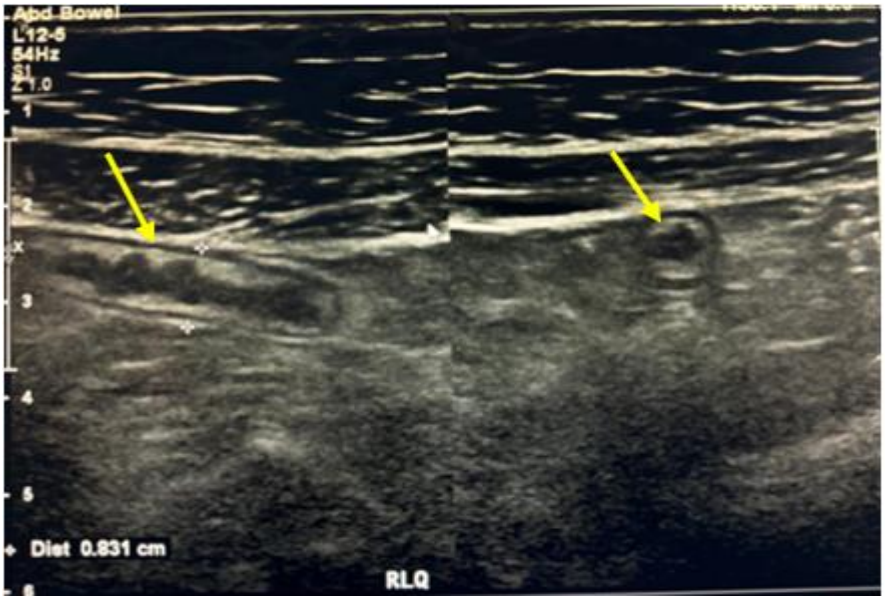

Figure 3.
35 years- old-male presented with acute abdomen pain- and tenderness of the right iliac fossa. US axial and sagittal images show dilated appendix (0.81 cm) (arrows) Appendicolith were detected in 9% of cases (figure 4). Detailed US findings are shown on Table 4.

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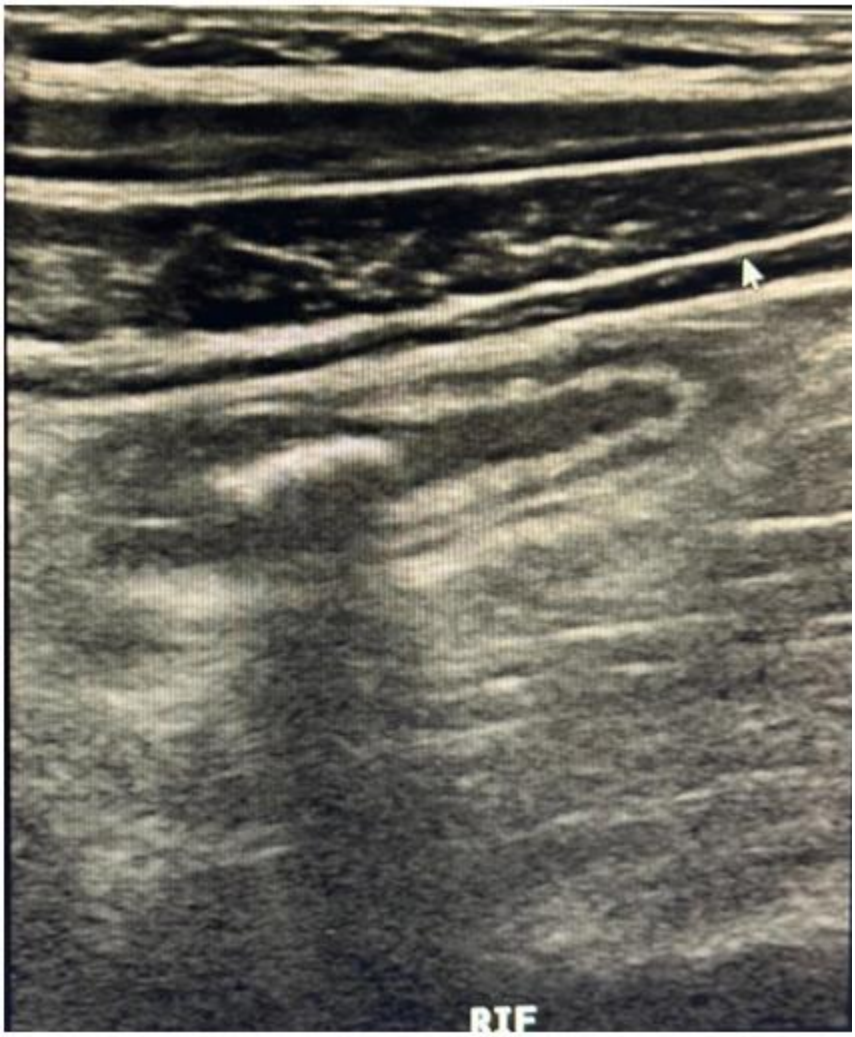

Figure 4.
14 years -old - male presented with abdominal Pain and tenderness of the right iliac fossa with fever and vomiting. US shows dilated appendix with a large appendicolith within (arrow).

Table 4.
US findings of patients.

	Frequency	Percent
Limited examination	27	27.3
Dilated appendix	23	23.0
Fluid collection	22	22.0
Thickened wall	13	12.9
Appendicolith	9	9.1
Doppler	5	5.0
Perforated	5	5.0
Abscess	1	1.0

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CT was beneficial in cases of degraded US images due to gaseous distension of the colon as shown in Figures 5 &6

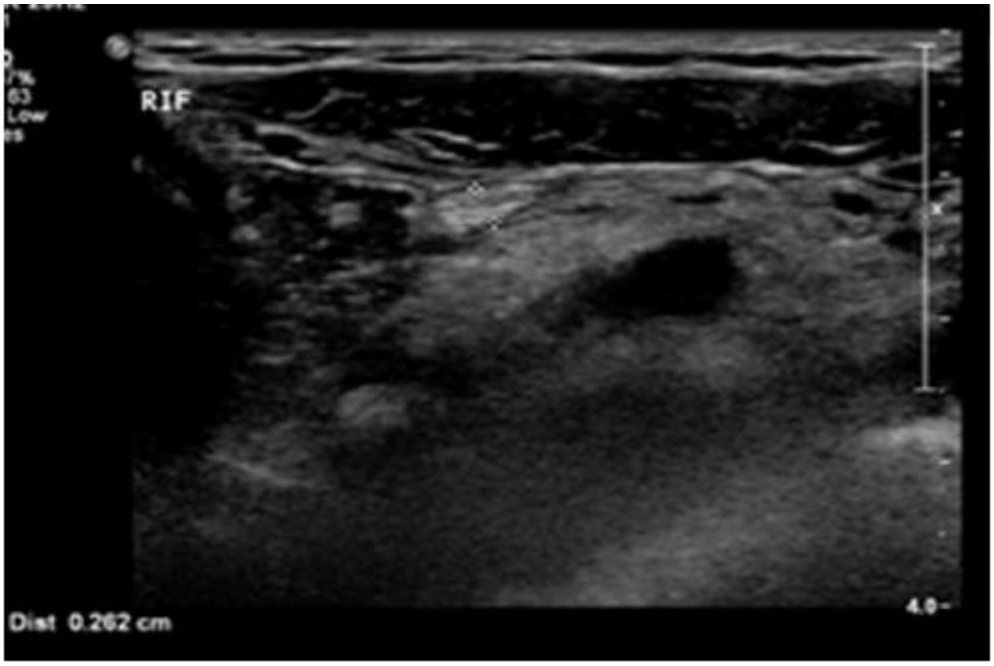

Figure 5.
11years- old- female patient presented with fever, vomiting and typical appendicitis pain. US shows the appendix in the right lower quadrant measuring 2.6 mm with no surroundings inflammatory changes. US was limited due to gasses distention of the colon (degraded the images), so they ordered for CT scan in (Figure 6)

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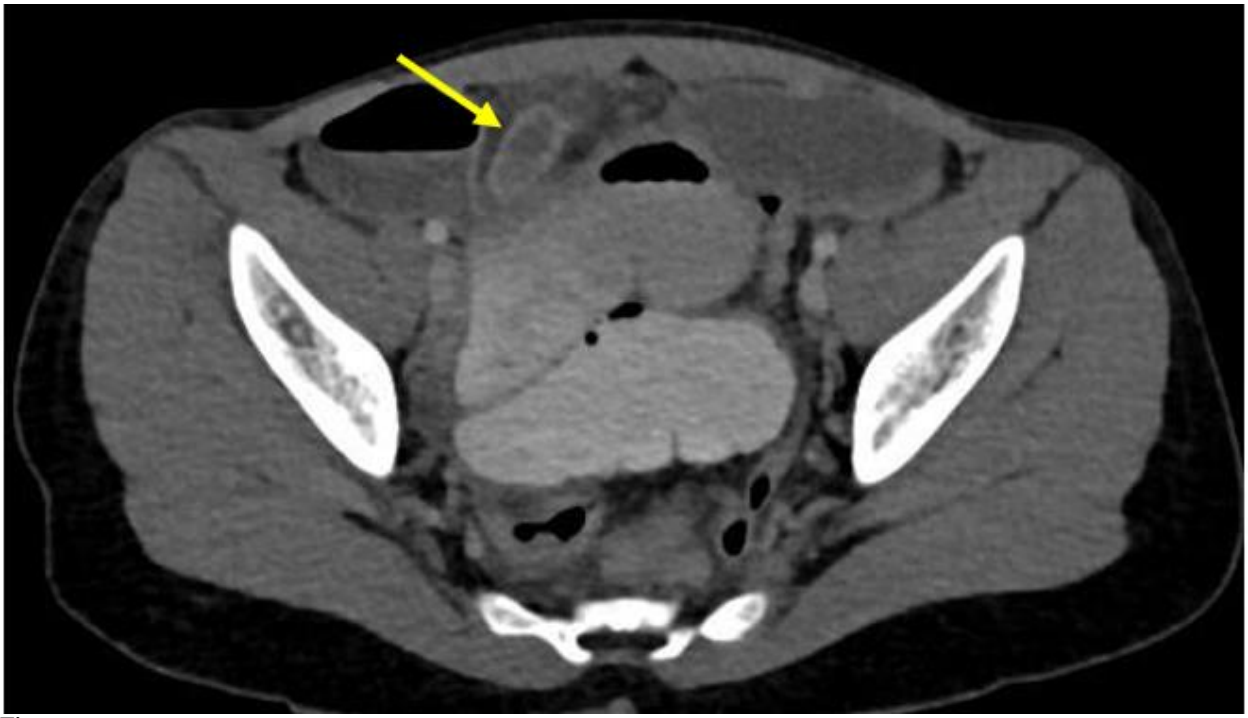

Figure 6.
Her CT scan shows a dilated appendix (9 mm) with an enhancing thick wall associated with remarkable peri appendiceal inflammatory changes (arrow).

The small and proximal large bowel loops appear dilated (maximum ileal loop diameter reaches 3.3 cm), and fluid filled with air fluid levels. No definite transition zones, this is likely functional obstruction.

CT can accurately diagnose complicated cases as well as additional findings that are not fully diagnosed using US (figures 7 &8).

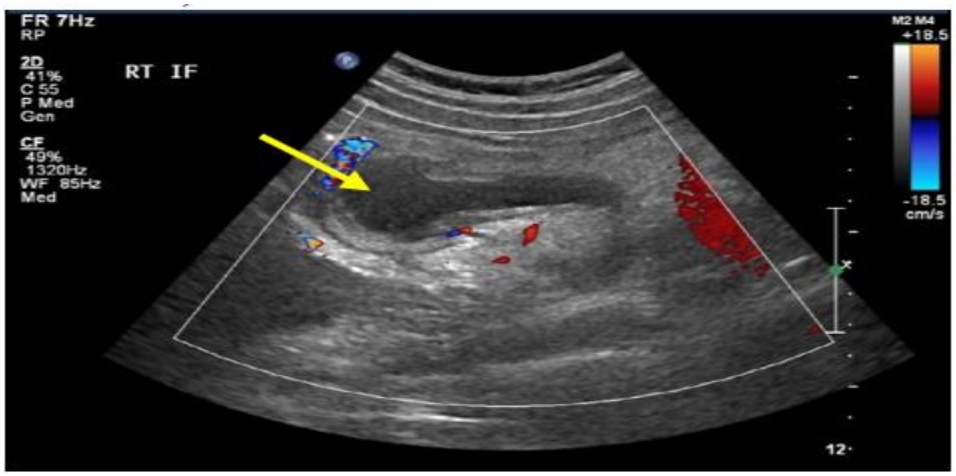

Figure 7.
A 29y/o male patient presented with severe abdominal pain.

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Ultrasound shows a well-defined tubular blind ending structure measuring 2 x 3 cm in the right iliac fossa connected to a large rounded enhance thick-walled cystic structure (arrow) measuring 2x3 cm, for further evaluation, CT abdomen was requested (figure 8).

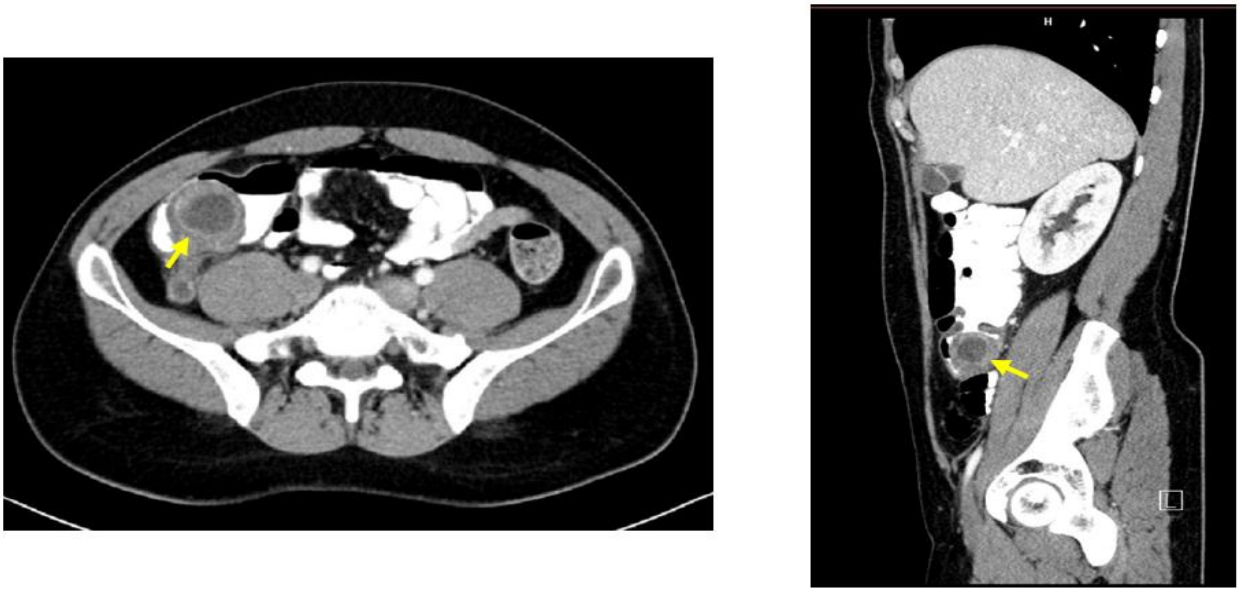

Figure 8.
CT shows an enlarged appendix measuring 1.3 cm, associated with wall enhancement and peri appendiceal fat stranding and small reactive lymph nodes.

An appendiceal mucocele complicated by appendiceal intussusception was diagnosed (arrow).

For assessment of the sensitivity of CT in diagnosis of appendicitis compared to that of US, participants were categorized into patients with no evidence of appendicitis and patients with one or more evidence (finding) for appendicitis. The sensitivity of each modality is shown in Table 5.

Table 5.
Sensitivity of CT and US.

		Frequency	Percent
CT examination (n=168)	One or more evidence	168	100%
US examination (n=62)	No evidence	23	37.1
	One or more evidence	39	62.9

The sensitivity of CT for diagnosis of appendicitis 100% and the sensitivity of US in diagnosis of appendicitis 63%

Most patients have 2 CT diagnostic findings of appendicitis (39%) followed by 3 findings (28%). While the least number of patients showed 7 findings (1%) as shown in Table 6.

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Table 6.
Number of CT findings in the patients who underwent CT examination (n=168).

	Frequency	Percent of total	Percent of CT performed
No CT examination		17.6	
1 finding	15	7.4	9%
2 findings	65	31.9	39%
3 findings	47	23	28%
4 findings	31	15.2	18%
5 findings	6	2.9	4%
6 findings	3	1.5	2%
7 findings	1	0.5	1%

There was no statistical difference in number of CT findings in age groups ≥10 years. (P value = 0.35 among the 2 groups; 10-30 and >30 years old) as shown in Table 7.

Table 7.
Number of CT findings in the different age groups.

	Number of CT findings	Age groups			Total
		<10	10-30 yrs	>30 yrs	
1 finding	Count	0	10	5	15
	%	0.00%	9.60%	8.20%	8.90%
2 findings	Count	1	35	29	65
	%	33.30%	33.70%	47.50%	38.70%
3 findings	Count	1	28	18	47
	%	33.30%	26.90%	29.50%	28.00%
4 findings	Count	0	25	6	31
	%	0.00%	24.00%	9.80%	18.50%
5 findings	Count	0	5	1	6
	%	0.00%	4.80%	1.60%	3.60%
6 findings	Count	0	1	2	3
	%	0.00%	1.00%	3.30%	1.80%
7 findings	Count	1	0	0	1
	%	33.30%	0.00%	0.00%	0.60%

Most of patients (81%) were managed by laparoscopic appendicectomy, while laparotomy was done for 25 (12%) patients, including all patients with perforated appendix. Conservative therapy and follow up was decided for only 14 (7%) patients (figure 9).

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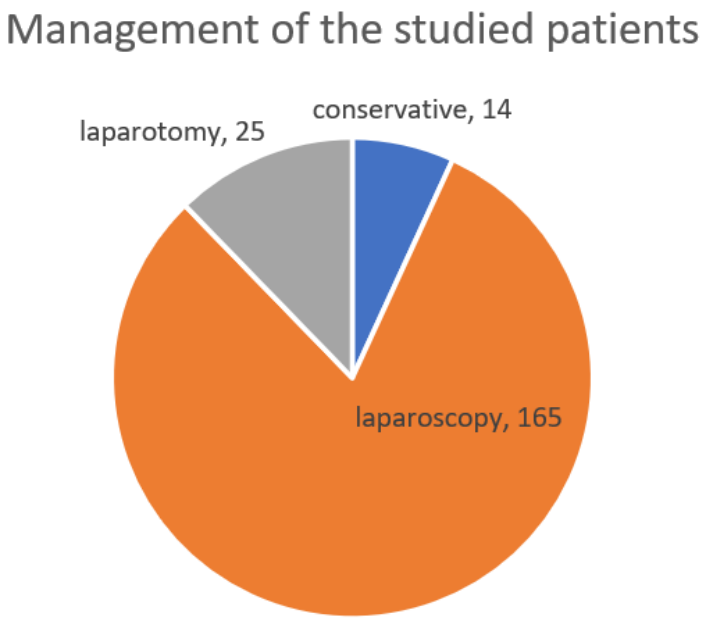

Figure 9.
Management of the patients.

6. Discussion

By discussing US and CT results with surgeons in King Abdulaziz university hospital, they mentioned that they prefer CT scan as a first line imaging modality in determining the diagnosis and decision about acute appendicitis, owing to its high diagnostic accuracy of appendicitis and its complications in addition to its ability to exclude other abnormalities that give the same clinical picture but may not need urgent surgical intervention.

Our study revealed that CT scan was requested for 142 patients while 35 patients only were referred to Ultrasound. In addition, 27 patients were referred to both CT scan and Ultrasound. The sensitivity of CT scan and Ultrasound in diagnosing appendicitis is (100%) and (63%) respectively. However, according to (Poortman et al., 2003), the sensitivity of CT scan and Ultrasound in diagnosing acute appendicitis were more or less equal (76%) and (79%) respectively.

Our study approved that CT scan is more accurate than Ultrasound in diagnosing acute appendicitis. Ultrasound is non-invasive, radiation free, inexpensive and requires no special preparations or contrast agent administration but it depends on the skills and expertise of the operator. Whereas CT scan is operator independent, it is easy to be performed and interpreted with accurate findings due to its several scanning protocols, reconstruction, and contrast administration.

In addition, some Ultrasound images could suffer from a degradation in their quality, either due to obesity and lots of abdominal fats, reactive abnormal dilation or gaseous distention of the colon because of the inflammatory process, or due to improper preparation for the Ultrasound examination in case of emergency. These factors contribute to the lower sensitivity of US than CT in detection of appendicitis. That is why CT scan would eliminate the limitations of Ultrasound.

Analysis of our data indicated that acute appendicitis is most common in age

of 10-30 years and males are more affected than females. These findings are supported with many studies which showed that adult males have a higher risk to develop acute appendicitis than females [11].

Most patients in the current research presented with typical appendicular pain (77%) followed by vomiting (56%). Much research that studied appendicitis have more or less similar results regarding clinical presentation of acute appendicitis with some differences in the percentage of each. Abraham D,

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2003 mentioned that the clinical presentation of appendicitis was abdominal pain in all patients, with shifting pain in (80.5%) and vomiting in (76.9 %). Furthermore, localized tenderness in the right lower quadrant was noted on examination in (92.4%), with rebound tenderness in (70.4%)- which is much more than our results (29.9%). Bowel habit changes, including diarrhea and constipation, were not common (7.6%) and (6.9%) of his patients, respectively and also in our research (14% and 5.6%) 12. Other research supported that the commonest clinical presentation of appendicitis is right lower quadrant pain e.g.

Nshuti R, 2014 who mentioned that right iliac fossa pain (95%) and vomiting (73%) were the most common presenting symptoms, followed by a typical acute appendicitis presentation (31%), and nausea (80%) [6] .

We relied on seven diagnostic criteria for diagnosing appendicitis by CT which are very similar to previous publications e.g. Kus et al, 2022 who used a CT appendicitis score as shown in table (8).

Table 8.
CT appendicitis score table [13].

	0	1	2	3
Severity of mural enhancement		Mild	Severe	
Wall thickness of appendix	<3 mm	≥3 mm		
Intraluminal appendicolith	–	+		
Intra-abdominal free fluid	–	+		
Appendiceal diameter		≤9 mm	10-12 mm	≥13 mm
Maximum size of peri cecal lymph node		≤10 mm	>10 mm	
Adjacent organ findings	–	+		
Severity of peri appendiceal fat stranding	–	Mild	Severe	

Fortunately, the majority of CT scans for appendicitis may be simply read as positive or negative. There are usually many positive findings when appendicitis is presented, such as appendiceal dilation, nearby inflammatory stranding or fluids, or the existence of an appendicolith. The range of normal and pathological appendiceal diameters has been found to overlap in several investigations. Abraham, 2003 found out that the average diameter of a typical appendix was 6.6 mm (for patients who are having CT scan for reasons other than suspected appendicitis). Our result showed that the most sensitive finding in CT imaging was dilated appendix (sensitivity 84%) almost above 7mm. 12

Detection of appendicoliths within thickened appendix was a useful diagnostic finding of appendicitis as well as inflammatory changes in and around appendix 12. Appendicoliths were identified at CT in nearly 40% of adults with proven appendicitis, compared with slightly more than 4% of those without appendicitis, and were associated with increased inflammation and risk of perforation.13 appendicoliths were not that common in our research. It was detected in 21% of our cases and all cases were associated with fluid and inflammatory changes.

When using CT to diagnose acute appendicitis, the most critical findings are inflammatory alterations in the Peri cecal and Peri appendiceal fat and that matched our results where some cases showed significant fat stranding and few reactive lymph nodes with most of the patients. 6.

In a study of (Balthazar and Gordon, 1989), abscesses were the second most prevalent abnormality in his patients with appendicitis (55%). They appeared as ill-defined or partially encapsulated extraluminal, low-attenuated fluid collection14. Only 2.9% of our cases showed abscess formation and all of them had appendicoliths. This variation may be referred to earlier presentations of our participants.

Strategies for imaging patients with suspected appendicitis usually revolve around clinical probability of the disease (using one of many available clinical prediction/decision rules), in which—if

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imaging is to be performed—this may start with CT first, or US first with conditional CT when US is inconclusive 15.

Specific patients' demographics are important before selecting the appropriate imaging modality to diagnose appendicitis. US should be the first strategy in children and women of child-bearing age as differential diagnoses are often vast and also to reduce radiation burden [19, 16].

For the rest of population, CT is often considered the most appropriate first imaging test owing to its high accuracy for both diagnosis, characterization of appendicitis and strong ability to suggest alternative diagnosis [20], but value of the US-first strategy with conditional CT or even US re-evaluation after an equivocal CT cannot be understated [17].

This study has a few limitations such as missing several patients' data because of the changing and updating in the Radiology information system of the hospital

Conclusion and recommendations:

Based on our results, CT is highly sensitive in diagnosing cases with uncomplicated and complicated acute appendicitis. The commonest findings in CT scan were dilatation and wall thickening of the appendix for patients presented clinically with typical appendicular pain and vomiting.

We recommend that any case with suspected acute appendicitis should start with CT scan as a first imaging modality; especially with patients with atypical clinical findings of acute appendicitis to exclude other causes of abdominal pain. That is due to the high sensitivity of CT scan which may reach up to 100% and being operator independent, unlike Ultrasound which is considered operator dependent and requires excellent and professional sonographers who can deal with cases at the emergency department which could not be available at all hospitals.

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