ACCURACY OF ULTRASOUND IN THE DETECTION OF APPENDICITIS

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Abstract: Ultrasound (US) is the preferred first-line imaging modality for diagnosing in acute appendicitis. The published sensitivity and specificity of ultrasonography are higher than the results observed by clinicians in everyday practice. The aim of this study was to elucidate the real-world value of ultrasonography in the diagnosis of appendicitis and its impact on negative appendectomy rates. This prospective study took place in the Department of Radiology at Ajalla Hospital in Benghazi, Libya, over 8 months. The study included 350 cases of clinically suspected appendicitis diagnosed using ultrasonography. All patients were evaluated clinically and underwent imaging, with findings confirmed by perioperative and histopathological results. A total of 350 cases of appendicular pathologies were studied, with a mean patient age of 31.50 (±13.40) years, ranging from 7 to 40 years. Forty-one percent of patients were aged 20-30 years, with 53% females and 47% males. The most common finding was a classical inflamed appendix (34%). The second most common finding was a distended, uncompressed cecum (28%), with other findings including focal dilated terminal ileum, free fluid in the ileocecal region with focal dilation, and free fluid in the ileocecal region, accounting for 17%, 11%, and 10% of cases, respectively. All operated cases were confirmed to have appendicitis on histopathological examination. It can be concluded that ultrasound assessment of the appendix is very accurate in diagnosis, with additional advantages over other radiological imaging techniques such as wide availability, simplicity, low cost, noninvasiveness, and lack of the need for ionizing contrast material. Furthermore, ultrasound can help exclude other causes of right iliac fossa pain.

Keywords: Ultrasound scan, appendicitis, accuracy, Ajalla hospital, Benghazi, Libya

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1. Introduction

Acute appendicitis is the most common surgical abdominal emergency with a life time prevalence of one in seven. The diagnosis is mainly clinical but because of innumerable presentation it is correct in up to 80% of the patients (Stephens & Mazzucco, 1999). This resulted in negative appendicectomy rate of 20 to 30% that had been considered acceptable (Snell, 2008). The removal of normal appendix is not a benign procedure and negative appendicectomy carries a definitive morbidity (Seal, 1981). Therefore, as ultrasound assessment (US) of appendix is very accurate in diagnosis, Ultrasound scan has a fundamental role in assessing appendix & by assessing its increase of dimensions, surrounding fat inflammation, distended uncompressed cecum & focal free fluid in terminal ileum. However, the diagnosis given on ultrasound must be confirmed on per-operational findings. That is, the decision to perform appendectomy or to treat a patient conservatively should be made in association with clinical findings (Snell, 2008). To reduce the rate of negative appendectomy and to improve the sensitivity of the diagnosis, physicians use sonography as a first line techniques used. The method of graded compression sonography is well established by several large prospective trials that have reported sensitivities of 77-89% and specificities of 94-96% (Chan et al., 2005).

There are multiple sonographic features to diagnose appendicitis, however: a threshold of 6-mm diameter of the appendix under compression is the most accurate US finding for appendicitis and has high negative predictable value (NPV) and positive predictable (PPV) (Kessler et al., 2004). Guidelines recommending against the use of CT for very high-risk and low-risk categories (NPV>95% and PPV>95%) on the basis of combined US and laboratory data could have reduced the number of CTs by 27.1% during the study period (Anandalwar et al., 2015). the sensitivity, specificity and accuracy of ultrasound for making a diagnosis of appendicitis were 97.6%, 82.0 %, 91.5 %, respectively (Himeno et al., 2003). Furthermore; Ultrasound is useful in the assessment of patients with conditions which can clinically mimic acute appendicitis such as Crohn's disease, tuboovarian abscess, typhilitis, sigmoid diverticulitis, perforated sigmoid neoplasm, perforated peptic ulcer, perforated acute cholecystitis, caecal carcinoma and appendiceal tumours (Ripollés, 1998). White blood cell count is helpful in the diagnosis and exclusion of appendicitis. However, there is no value to differentiate advanced appendicitis (Keskek et al., 2008).

Patients who undergo Negative Appendectomy to treat suspected appendicitis experience considerable clinical and financial implications. These should be considered when considering system-level initiatives to improve the management of appendicitis (Flum & Koepsell, 2002). The aim of the study was to assess the role of ultrasound in the evaluation of the appendix and to correlate the findings with surgical results. This prospective study was conducted at the Department of Radiology, Ajalla Hospital in the city of Benghazi, Libya. Abdominal ultrasound studies were performed on 350 cases to accurately diagnose clinical and surgical conditions involving the appendix. Out of the 350 patients diagnosed by ultrasound, the most common complaint seen in our study as right iliac fossa (R.I.F) pain, which was indicative of acute appendicitis. This study was aimed at evaluating the role of ultrasound in the diagnosis of appendicitis, discuss the imaging spectrum of common appendicitis, correlate findings with surgical results, and finally discuss the traditional treatment methods.

2. Anatomy

The appendix is a wormlike extension of the cecum and, for this reason, has been called the vermiform appendix. The average length of the appendix is 8-10 cm, ranging from 2-20 cm. The appendix appears during the fifth month of gestation, and several lymphoid follicles are scattered in its mucosa. These follicles increase in number when individuals are aged 8-20 years.

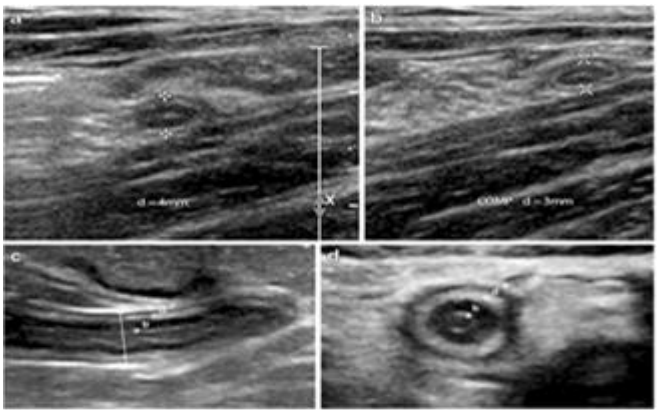


Figure 1. normal appendix. a, b Transverse gray-scale US images with (a) and without (b) compression (COMP) in a 9-year-old girl show the appendix is normal size and compressible. c, d Magnified longitudinal (c) and transverse (d) gray-scale US views of the normal appendix in a 12-year-old boy show alternating echogenicities of the normal layers of the appendiceal wall, including echogenic mucosa (a), hypoechoic muscularis mucosa (b), echogenic submucosa (c), hypoechoic muscularis propria (d) and echogenic serosa (e).

Source: Anandalwar et al. (2015)

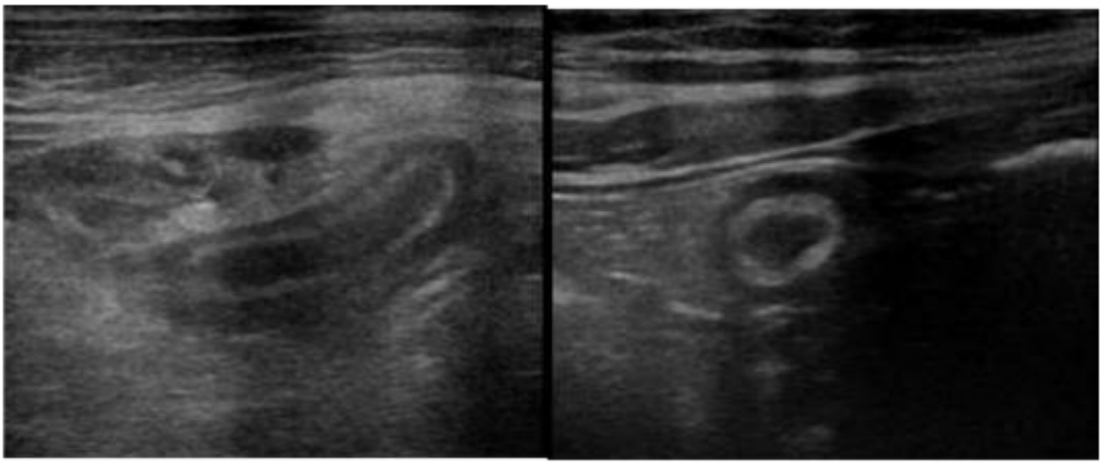
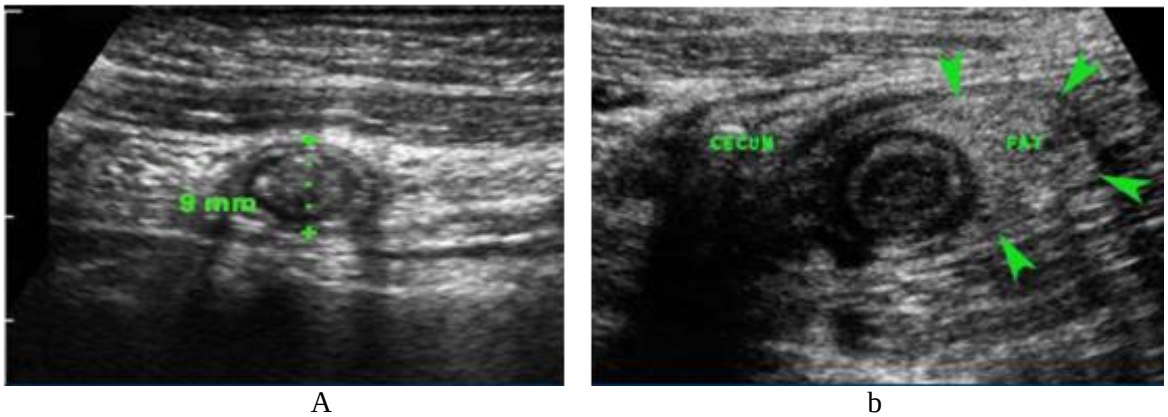


Figure 2. Acute appendicitis - Longitudinal and axial scan showing blind ended, tubular, distended, appendix with hypoechoic wall suggestive of inflamed appendix
Source: Authors



A b

Figure 3. Increase transvers diameter in inflamed appendix (a), and inflamed surrounded fat (b).
Source: Puylaert (2020)

The appendix is contained within the visceral peritoneum that forms the serosa, and its exterior layer is longitudinal and derived from the taenia coli; the deeper, interior muscle layer is circular. Beneath these layers lies the submucosal layer, which contains lymphoepithelial tissue. The mucosa consists of columnar epithelium with few glandular elements and neuroendocrine argentaffin cells. Taenia coli converge on the posteromedial area of the cecum, which is the site of the appendiceal base. The appendix runs into a serosal sheet of the peritoneum called the mesoappendix, within which courses the appendicular artery, which is derived from the ileocolic artery. Sometimes, an accessory appendicular artery (deriving from the posterior cecal artery) may be found.

3. Appendiceal vasculature

Addressing the vasculature of the appendix is crucial to avoid intraoperative hemorrhages. The appendicular artery is located within the mesenteric fold which extends from the terminal ileum to the medial aspect of the cecum and appendix. It is a terminal branch of the ileocolic artery and runs adjacent to the appendicular wall. Venous drainage occurs through the ileocolic veins and the right colic vein into the portal vein. Lymphatic drainage occurs through the ileocolic nodes, following the path of the superior mesenteric artery to the celiac nodes and cisterna chyli.

4. Appendiceal location

The appendix does not have a fixed position. It typically originates 1.7-2.5 cm below the terminal ileum, either in a dorsomedial location (most common) from the cecal fundus, directly beside the ileal orifice, or as a funnel-shaped opening (2-3% of patients). The appendix is retroperitoneal in 65% of patients and may descend into the iliac fossa in 31%. In fact, many individuals may have an appendix located in the retroperitoneal space; in the pelvis; or behind the terminal ileum, cecum, ascending colon, or liver. Therefore, the course of the appendix, the position of its tip, and the difference in appendiceal position significantly impact clinical findings, contributing to the nonspecific signs and symptoms of appendicitis.

5. Materials and Methods

The study involved 350 cases of clinically suspected appendicitis diagnosed through ultrasonography. All patients underwent clinical evaluation and imaging, with findings later confirmed through peri-operative and histopathological results. This prospective study was conducted at the Department of Radiology in Ajalla Hospital, located in the city of Benghazi, Libya, over an 8-month period. The ultrasound machines and transducers used were PHILIPS 21 IU with a longitudinal array and a frequency of 9-12 Hz. Inclusion criteria included all cases that complained of right iliac fossa pain and were clinically suspected of appendicitis while exclusion criteria contained all cases suspected clinically but with other possible differentials proven on ultrasound showing a normal appendix were not included in this study. For each patient a questionnaire was filled out including age, gender, WBC count, operation findings, and USS findings.

6. Results analysis

A total of 350 cases presenting with right iliac fossa (RIF) pain were studied, and the results will be discussed in relation to each variable. As depicted in Figure (4), the majority of cases fell within the 20-30 age range, making up approximately 41% of all cases. Furthermore, appendicitis was less common in other age groups, with 27% of patients aged 10-20, 12% aged 0-10, and finally, 9% aged over 50.

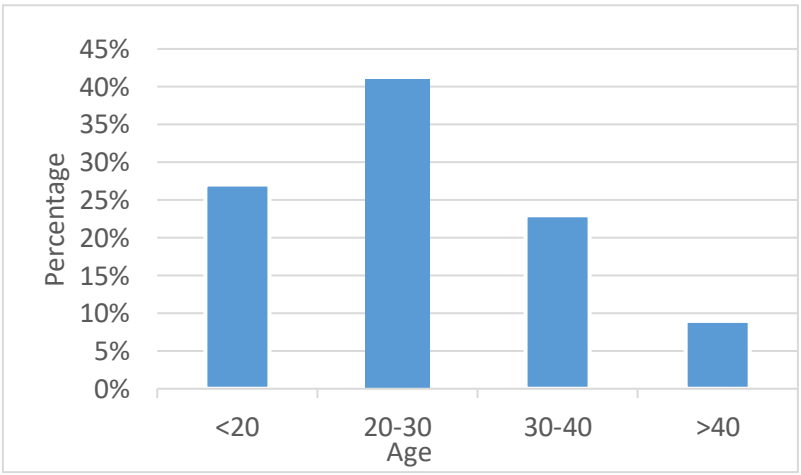


Figure 4. Shows the age distribution of the patient

As for gender, it was observed, as in Figure (5), that the majority of the cases were females with predominance about 53% over male patients predominance

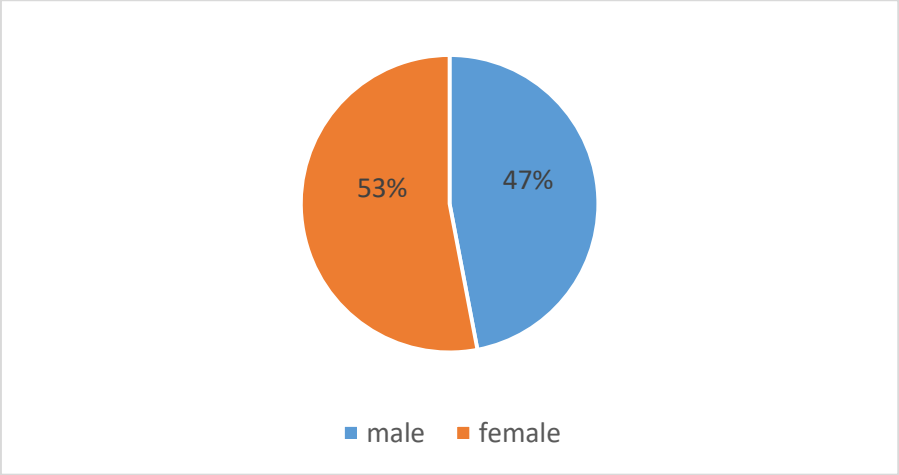


Figure 5. Prevalence to the gender

Regarding the ultrasound findings of the patients, as illustrated in Table (1) most of them had classical inflamed appendix that reveal increase in the diameter (>6mm) (34%). The second most common finding was distended uncompressed cecum (28%), while the other findings were presence of appendicolith, free fluid in ileocecal region and inflamed surrounded fat being 11%, 17and 10% of the cases, respectively.

Table 1. Sonographic features of appendicitis

Sonographic finding	Frequency
Increase appendix diameter	34%
Distended uncompressed cecum	28%
Free fluid in ilo-ceal region	17%
Appendicolith	11%
Inflamed surrounded fat	10%

However, when we discuss the colarration of The white blood cell count of the patients that reviewed in Table (2) is display no colerration between the WBC count and the severity of the disease the result revealed Approximately 23% of the cases showed a normal WBC count with 10% having 1,000-5,000WBC/µL; and 13% having 5,000-10,000WBC/µL. However, the majority of patients had elevated WBC counts with around 32% of them having 10,000-15,000WBC/µL, 33% having 15,000-20,000WBC/µL, and 11% with more than 20,000 WBC/µL.

Table 2. Laboratory results of White Blood Cells (WBC) counts as an inflammatory marker

	WBC count	Frequency
Normal	1,000-5,000WBC/µL	10%
	5,000-10,000WBC/µL	13%
Elevated	10,000-15,000WBC/µL	32%
	15,000-20,000WBC/µL	33%
	> 20,000 WBC/µL.	11%

As shown in Table (3), the findings revealed that the percentages of patients with different appendix locations were as follows: retrocecal inflamed appendix (58%), normal positioned inflamed appendix (32%), normal appendix (6%), para ilial inflamed appendix (1.3%), sub hepatic (High position appendix) (1.7%), and pelvic location inflamed appendix (1%).

Table 3. Post-operative results

Operation finding	Number	Frequency
retrocecal inflamed appendix	203	58%
Normal positioned appendix	113	32%
Normal appendix	20	6%
para ilial inflamed appendix	5	1.3%
Sub hepatic (High position appendix)	6	1.7%
pelvic location inflamed appendix	3	1%

7. DISCUSSION

The appendix, officially named of the veriform appendix, which means "worm-like appendage", is a small, pouch-like sac of tissue located in the first part of the colon (cecum) in the lower-right abdomen. Appendicular pathologies are the most frequently found cause of right iliac fossa pain. Visceral pain in the appendix is produced by distention of its lumen or spasm of its muscle. The afferent pain fibers enter the spinal cord in the 10th thoracic segment, and a vague referred pain is felt near the umbilicus. Later, the pain moves to where the infected appendix rubs the parietal peritoneum. Here, the agony is precise, severe, and confined.

The inconstancy of the position of the appendix should be borne in mind when attempting to diagnose appendicitis. A retrocecal appendix, for example, may lie behind a cecum distended with gas, and thus it may be difficult to elicit tenderness on palpation in the right iliac region. Irritation of the psoas muscle, conversely, may cause the patient to keep the right hip joint flexed (Chesbrough et al., 1993). Acute appendicitis (AA) is a common abdominal emergency with a lifetime incidence of approximately 7%. As the clinical diagnosis of AA remains a problem for emergency physicians and surgeons, imaging techniques have become more important in the diagnostic work-up of patients with suspected AA in order to keep both the negative appendectomy and perforation rates low. Introduced in 1986, graded-compression ultrasonography (US) has well-established direct and indirect indicators for AA diagnosis

Appendicitis was first popularized by Puylaert in 1986, who invented Graded compression technique where a uniform pressure is applied in right iliac fossa by a hand held ultrasound transducer. With this technique, normal and gas filled loops of intestine are either displaced from the field of vision or compressed between anterior and posterior abdominal walls. Inflamed appendix is incompressible is seen optimally as a blind ended tubular structure with laminated wall arising from the base of caecum. It is aperistaltic, non-compressible and it should have a diameter of more than 6mm. Similarly there may be increased echogenicity of the peri-appendicular mesenteric fat. A sensitivity of 89% and specificity of 100% for this technique were reported for the diagnosis of acute appendicitis (Mostbeck et al., 2016). When the appendix is normal, ultrasound plays a useful role in finding the cause of right pain such as mesenteric lymphadenitis, vesicoureteral junction (VUJ) calculus or a hemorrhagic ovarian cyst. Ultrasound assessment of the appendix is very accurate in diagnosis. This along with other advantages over other radiological imaging techniques such as its wide availability, simplicity, low cost, noninvasiveness and lack of need of ionizing contrast material. Ultrasound is also used to visualize other structures near the appendix to rule out other diagnoses such as colitis, vesico-ureteric junction stones, and adnexal pathologies. It is almost confirmatory for appendicular pathologies, especially acute appendicitis, but sometimes Computed Tomography (CT) scanning is used for confirmation in complicated cases such as gangreneuse appendicitis and evaluation of a retro-caecal appendix.

8. Conclusion

Ultrasound assessment of the appendix is highly accurate in diagnosing appendicitis. In addition to this, it has several advantages over other radiological imaging techniques including its widespread availability, simplicity, low cost, non-invasiveness and lack of need or ionizing contrast material. Ultrasound can also be used to assess the differential diagnosis of right iliac fossa pain.

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