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THE UTILITY OF ULTRASONOGRAPHY COMPARED TO SURGICAL AND PATHOLOGY FINDINGS IN EVALUATING SUSPECTED ACUTE APPENDICITIS AT A TERTIARY INSTITUTION IN KENYA
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THE UTILITY OF ULTRASONOGRAPHY COMPARED TO SURGICAL AND PATHOLOGY FINDINGS IN EVALUATING SUSPECTED ACUTE APPENDICITIS AT A TERTIARY INSTITUTION IN KENYA

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ABSTRACT

***Objective*: To investigate the role of ultrasonography in evaluating patients with clinical suspicion of acute appendicitis.**

***Design*: A prospective descriptive study of patients clinically suspected to have acute appendicitis. The abdominal sonographic findings were correlated to the surgical and pathology results.**

***Setting*: Kenyatta National Hospital and the Department of Diagnostic Imaging and Radiation Medicine, University of Nairobi.**

***Subjects*: Patients with a clinical suspicion of acute appendicitis referred for abdominal ultrasonography during the study period.**

***Results*: A total of 112 patients were recruited following ethical approval and informed consent. Males were 73 and females 39 giving a male to female ratio of 1.9:1. The age distribution was from 8 to 70 years with a median age of 27.1 years (IQR 11.5, Q1 = 19.6, Q3=37.1). All patients presented with abdominal pain which was localized at the right iliac fossa in 96 (86%) patients and generalized in 16 (14%). Ultrasound examination of abdomen showed that 97 (87%) patients had findings concerning for appendicitis. The rest (15) patients did not have sonographic features concerning for appendicitis. All patients underwent appendicectomy and 61(54.5%) had inflamed appendices, 32 (28.6%) perforated appendices, 27(24.1%) abscess and 5(4.5%) were gangrenous. The histology of the excised appendices resulted in accuracy, sensitivity, specificity, PPV and NPV of sonographic diagnosis of acute appendicitis to be 88.4%, 92%, 58.3%, 95% and 47% respectively. The overall negative appendicectomy rate was 10.7%.**

***Conclusion*: Abdominal ultrasonography using graded compression technique is a useful tool for evaluation of suspected acute appendicitis. However, the ultrasound findings should always be carefully correlated with clinical findings since its negative predictive value is quite low (47%).**

INTRODUCTION

Acute appendicitis is the most common surgical abdominal emergency with a life time prevalence of one in seven (1). Reported risk factors include young age with peak incidence at 10-19 years, male gender and Caucasians (2). Epidemiological studies have shown that the incidence of acute appendicitis has declined from approximately 1 in 400 (4) to 1:1000 (2). However, the incidence in Africa, though reported to be low is showing an upward trend with the peak incidence being in the third decade (3).

The diagnosis of acute appendicitis is mainly clinical but because of its nonspecific presentations, this diagnosis is correct in up to 80% of the patients (4, 5). As the consequences of missed diagnoses are serious, the common practice in surgery has been to operate on doubtful cases. This has resulted in a high negative appendicectomy rate of 20 to 30% (6). The removal of a normal appendix is not quite benign as it carries a definite morbidity. And whereas the role of the appendix has not been clearly determined it has been noted that the presence of many organized lymphoid aggregations indicate an immunological role (7).

To improve the pre-operative diagnostic accuracy of suspected appendicitis, different clinical and imaging protocols have been introduced (5, 7, 8). Among the imaging modalities, ultrasonography is the simplest, noninvasive, convenient and most cost-effective technique (7).

The use of sonography in the diagnosis of acute appendicitis was first popularized by Puylaert in 1986 (9). In this technique, gradually increasing pressure is applied to the right iliac fossa by a handheld ultrasound (US) transducer which displaces normal and gas-filled loops of intestine allowing visualization of any right iliac fossa (RIF) pathology (1,8,10). These authors have documented that the inflamed appendix is an incompressible, blind-ended aperistaltic tubular structure with laminated walls and a diameter equal or greater than 6 mm. Additional contributory findings which lead to the diagnosis of acute appendicitis include appendicoliths which appear as bright echogenic foci with distal acoustic shadowing, RIF fluid and increased echogenicity in the periappendiceal fat (10, 11). Puylaert (1986) reported a sensitivity of 89% and specificity of 100% of ultrasound graded compression technique in the diagnosis of acute appendicitis (10).

After the pioneer article by Puylaert in 1986, several workers have studied the role of ultrasound in the management of suspected acute appendicitis. Most of these authors have shown reports of increased diagnostic accuracy when ultrasound evaluation was added to the clinical work up of the patients as it significantly reduced the number of false positive and false negative results (8, 10, 12, 13). The objectives of the study were to determine the accuracy of abdominal ultrasound in patients with clinical suspicion of acute appendicitis using surgical and pathology findings as the gold standard. We also determined if ultrasound had a role in demonstrating differential diagnoses of acute appendicitis.

MATERIALS AND METHODS

All patients suspected to have acute appendicitis based on history and clinical examination, were recruited into the study. Ethical approval was granted by the Kenyatta National Hospital-University of Nairobi (KNH-UoN) ethical review committee. Informed patient's consent was sought and

obtained from the participants. Purposive sampling method was used during the study period of March 2010 to November 2010.The patients underwent sonography followed by surgery. Histology reports of the excised appendices were obtained. Sonography was performed using high-resolution real-time scanners at the ultrasound units of KNH and department of Diagnostic Imaging and Radiation Medicine, UoN. Equipment used included General Electric (GE) ultrasound Logiq Q7, GE ultrasound Logiq 5 Expert, HP image point HX and Philips SD800 using high frequency linear transducers with multifrequency ranges of 3 to 12 MHz. No patient preparation was required. The sample size was calculated to be 100 using the Fischer et al formula (14) and a prevalence rate of 7% (6).

Ultrasound Technique: All the study participants were scanned in the supine position. A linear high-frequency probe (3-12MHz) ultrasound transducer was used to apply graded compression in the right lower quadrant of the abdomen. This technique allowed clear visualization of the right iliac fossa (RIF) contents. Additional Doppler evaluation of the appendix was done. The image acquisition and quality were maximized as much as possible considering the patients' body habitus. The sonographic features for acute appendicitis were non-compressible, blind-ended aperistaltic tubular structure with diameter greater than or equal to 6 mm in the right iliac fossa. The demonstration of appendicoliths, probe tenderness, increased echogenicity of the periappendiceal fat, free intraperitoneal fluid and circumferential flow on color Doppler ultrasound were additional collaborative findings for positive criteria in acute appendicitis.

A data collection tool was used to record the patient's sociodemographic characteristics, clinical, sonographic, surgical and pathology findings. The data was analyzed using SPSS computer package and presented in form of tables and graphs. To determine the correlation, cross tabulations between US, clinical and surgical findings and histology reports was done.

RESULTS

A total of 112 patients were scanned. Seventy-three (65.2%) were males and 39 (34.8%) females with M: F ratio of 1.9:1. Most of the participants (37.5%) were aged between 20 and 29 years and the least frequent age group was under 10 years at 4.5%. The median age was 27.1 years (IQR 11.5, Q1 = 19.6, Q3=37.1) (Table 1).

Demographic Characteristic	Frequency (n)	Percentage (%)
Sex		
Male	73	65.2
Female	39	34.8
Age group (in years)		
< 10	5	4.5
10 – 19	23	20.5
20 – 29	42	37.5
30 – 39	26	23.2
≥ 40	16	14.3
Total	**112**	**100.0**

Table 1: Distribution of study population by age group and gender (n=112) showing that the highest prevalence was in the 20-29 age group. The M:F ratio was 1.9:1

Regarding the clinical presentation, all the patients presented with abdominal pain which was localized in RIF in 86%. On examination, there was abdominal tenderness in 99% and rebound tenderness in 70% (Figure 1).

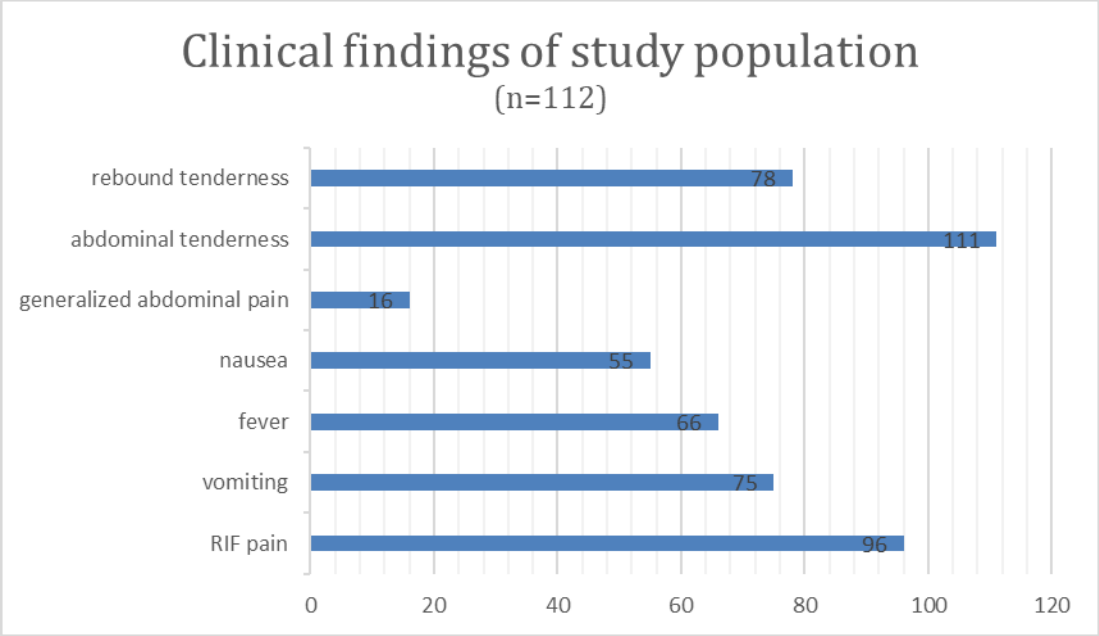

Figure 1: Clinical Findings of the study population (n = 112) showing that all the patients presented with abdominal pain which was localized in the RIF in 96/112 patients.

Sonographic findings are presented in table 2. The most common findings were maximal tenderness at RIF (68%), followed by blind ending tubular structure (60%) (image 1), RIF Fluid/Abscess (34.8%) (image 2) and high echogenic surrounding fat (22.3%). The least common finding was edema of the caecal pole at 4.5% followed by appendicolith at 10.7% (image 3) (Table 2).

Ultrasound characteristics	Frequency	Percentage (%)
Blind ending tubular structure	67	60
Non-compressible	*67*	
aperistaltic	*67*	
diameter ≥ 6mm	*64*	
diameter < 6mm	*3*	
Appendicoliths	12	10.7
High echogenic surrounding fat	25	22.3
Edema of caecal pole	5	4.5
Maximum tenderness at RIF	76	67.9
Circumferential colour on Doppler US	22	19.6
RIF fluid/abscess	39	34.8
Normal US findings	15	16

Table 2: Sonographic findings of study participants showing that the appendix was demonstrated in 60% of the examinations where it measured ≥ 6 mm in 96% of cases.

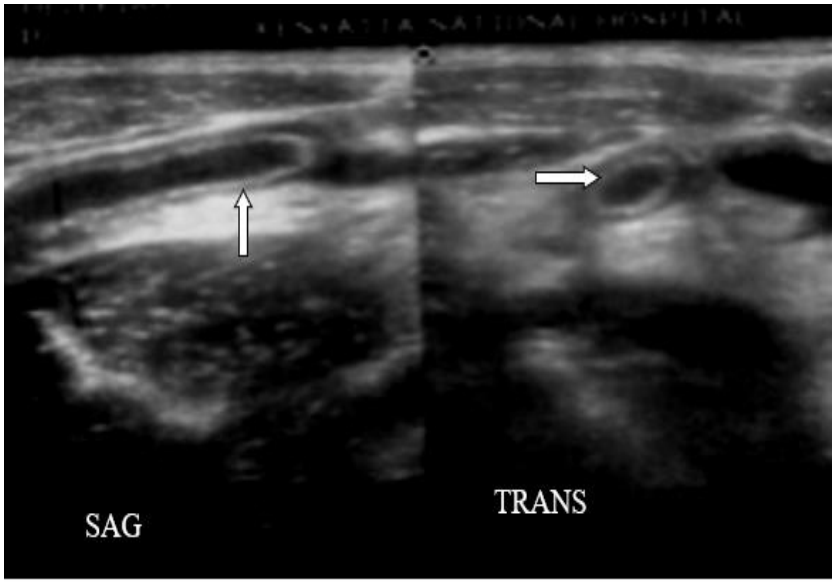

Image 1: Sagittal and transverse abdominal scan showing inflamed appendix (arrowed) with hypoechoic centre surrounded by hyperechoic rim which gives a target sign on transverse scan. The surrounding fat around was echogenic.

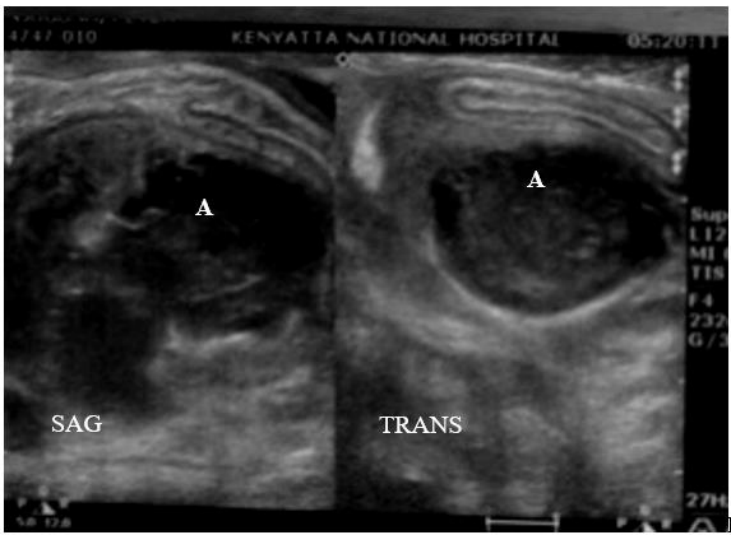

Image 2: Sagittal and transverse trans-abdominal RIF scan showing a complex mass/abscess (A). Intraoperative findings confirmed perforated gangrenous appendix with associated RIF abscess.

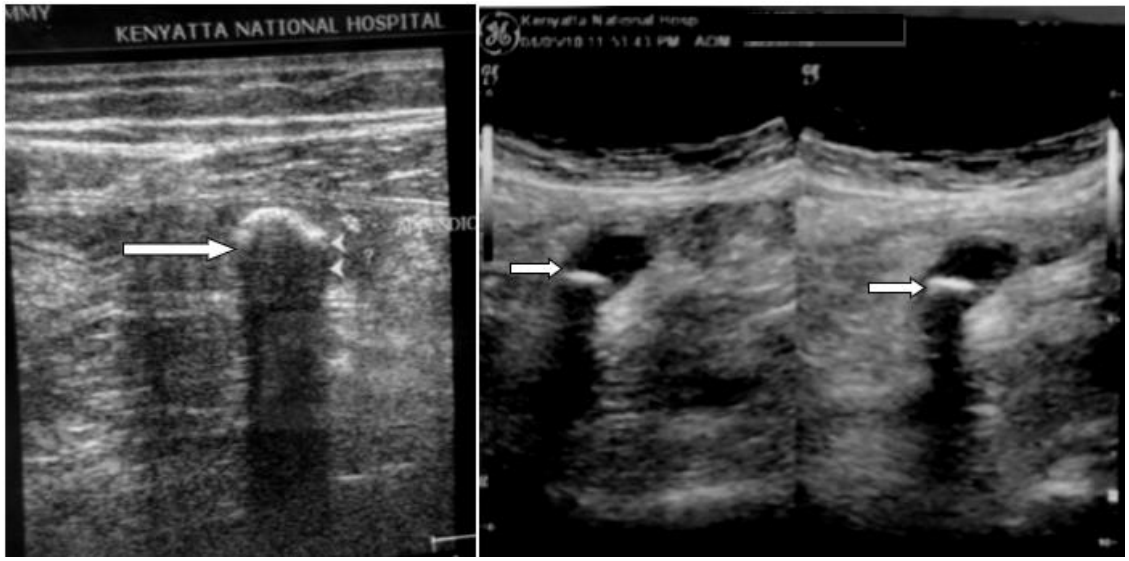

Image 3: Trans-abdominal scans of right iliac fossa from two different cases showing echogenic foci (arrowed) within blinded ending tubular structures. These are appendicoliths in patients with acute appendicitis.

At surgery, the appendices were inflamed at 54.5%, followed by perforated appendix (28.6%) abscess (24.1%) (images 2), and the least frequent surgical finding was gangrenous appendix at 5% (Table 3). The histological findings confirmed the diagnosis of acute appendicitis at 89.3%.

Surgical findings of excised appendix	Frequency (n=112)	Percentage
Inflamed	61	54.5
perforated	32	28.6
abscess	27	24.1
gangrene	5	4.5
Normal findings	13	11.6

Table 3: Surgical findings of the appendix showed that it was normal in only 11.64% of cases.

Correlation between ultrasound and histology showed that 61/67 patients who demonstrated blind-ended tubular structure on sonography were confirmed to have acute appendicitis on histology (Table 4). The least predictive sonographic findings in acute appendicitis were normal abdominal study with probability of 0.53 (95% CI: 0.27, 0.79) (Table 4).

Histology (n=112)	Ultrasound findings (n=112)							
	Blind ending (67)	Appendicolith (12)	High echogenic (25)	Caecal edema (5)	Maximal tenderness (76)	Doppler color flow (22)	RIF Fluid (39)	Normal findings (15)
Positive (100)	61	11	23	5	66	21	35	8
Negative (12)	6	1	2	0	11	1	4	7
Posttest probability (95 % CI using binomial tests)	0.91 (0.82-0.97)	0.92 (0.62-1.00)	0.92 (0.74-0.99)	1 (0.48-1.00)	0.86 (0.77-0.87)	0.95 (0.77-0.95)	0.90 (0.76-0.97)	0.53 (0.27-0.79)

Table 4: Ultrasound findings correlated with the histology findings shows that the most informative features for appendicitis on US were the blind-ending tubular appendix, periappendiceal echogenic fat, circumferential Doppler color flow and RIF fluid.

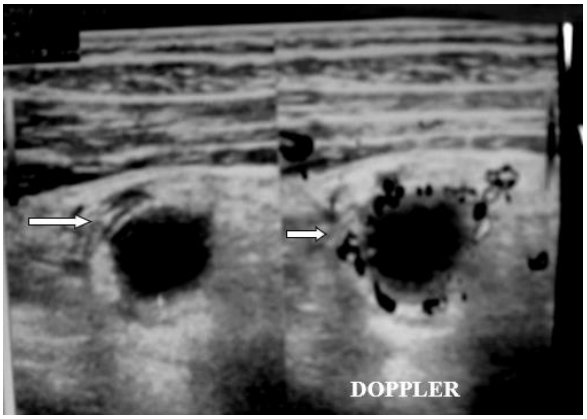

Image 4: Transverse scan of the right lower quadrant showing hypoechoic round lesion with a surrounding fat echogenicity and increased color blood flow around it (arrowed). Intra-operatively was confirmed to be an inflamed appendix.

Among the 97 patients with features concerning for acute appendicitis on ultrasound, 92 were proved positive on histology and 7 appendices were negative on both ultrasound and histology. Using histology as the gold reference standard; abdominal ultrasound was found to have a sensitivity of 92%, specificity of 58.3%, PPV of 95%, NPV of 47%, and accuracy of 88.4% (Fisher's test p-values < 0.0001) (Table 5). The negative appendectomy rate was 10.7%.

Table 5: Correlation of ultrasound findings and histology.

FREQUENCIES (n)		**HISTOLOGY**		
		+VE	**-VE**	**Total**
Ultrasound	Positive	92	5	**97**
	Negative	8	7	**15**
Total		**100**	**12**	**112**

There was a significant association between diameter of appendix on ultrasound examination and the histological finding (Fisher's exact test p-value =0.045). Patients with appendiceal diameters of 6mm or more sonographically were more likely to have acute appendicitis at histology (Table 6).

Table 6: Correlation of appendiceal diameter with surgery and histology.

Confirmed as appendicitis	**Ultrasound findings on appendiceal diameter (n)**		***p-value***
Surgical	**≥ 6 mm**	**< 6 mm**	
Positive (+VE)	57	1	*0.045*
Negative (-VE)	7	2	
Total	**64**	**3**	
Histology			
+ VE	64	0	*< 0.0001*
- VE	0	3	
Total	**64**	**3**	

Fisher's exact test p-value

Other intra operative peri-appendiceal findings which mimicked acute appendicitis clinically in this study included 5 cases of tubo-ovarian complex masses, 4 cases of peritoneal adhesions secondary to previous laparotomy, 4 cases of mesenteric adenitis and a single case each of Meckel's diverticulitis and typhoid enteritis.

DISCUSSION

This study has shown that the peak age of appendicitis in our local setting is between 20 and 29 years which is corroborated by Chavda (3) but contrasts with previous studies, which show a distinct prevalence of appendicitis in the 10-19 age group (2,6). The reason for the disease presenting more in the 3rd instead of the 2nd decade is not clearly understood but may be related to changes in dietary habits. Our study findings indicate an overall male predominance of 1.9:1 which correlates favorably with previous studies which showed a male predominance of 1.4-1.9:1 (2, 6, 15, 16)

Abdominal pain was found to be the main symptom of appendicitis as it was present in all the 112 patients which compares well with other earlier studies (17). Fever was also an important and prevalent symptom in our study at 59% (66/112) which was contrary to other studies where fever was reported at 33 - 37% (7, 8). It is postulated that the high percentage of patients with fever in our study could be related to the relative high complication rate at the time of presentation as the majority of the patients (57%) were found with perforation, gangrene and abscess formation which was not seen in the other studies. The high complication rate could be related to delay in patient presentation or the in-hospital turnaround times. Almost all the patients 111/112 (99.1%) in our study had abdominal tenderness. These findings compare well to a study done in Pakistan where the abdominal tenderness was elicited in 98.27% (17). In this Pakistani study the majority of the subjects, were children aged below 10 years who came from rural areas, which may have contributed to delayed diagnosis and intervention.

Acute appendicitis is a clinical diagnosis and no laboratory or radiological tests are 100% accurate. In equivocal and difficult cases, ultrasound examination of the abdomen and pelvis is usually recommended (8, 16, 18). In this study, the ultrasound sensitivity, accuracy, PPV rates for the diagnosis of acute appendicitis using ≥ 6mm diameter of

appendix was 92%, 88.4% and 95% (Table 5) which has been supported by several authors (8,19, 20). Other sonographic features which were found to aid in the diagnosis of acute appendicitis included maximum tenderness at RIF, high echogenic periappendiceal fat and RIF fluid (Table 2, image 2). These additional contributory findings in the diagnosis of acute appendicitis have been reported in several other studies (12, 15-17).

This study has shown that color Doppler ultrasound was very useful in detecting inflamed appendices as it showed circumferential increase in blood flow in 22 appendices; out of which there was a positive histological confirmation of inflammation in 21 giving a PPV of 95.4% (Image 4, Table 4). Similar findings have been reported in previous studies, but it should be noted that the sensitivity of color Doppler has been found to be relatively low in complicated appendicitis (13, 20).

The mimics of acute appendicitis found in this study have been reported by other researchers who found that gynecological disorders, mesenteric lymphadenitis, cholecystitis and hydronephrosis were alternative intraoperative findings (20)

Historically, the accepted negative appendicectomy rate has been about 20 - 30% (6). Careful clinical scoring methods and preoperative imaging has been widely adopted as a means of improving the accuracy of diagnosis of acute appendicitis and thereby reducing the negative appendicectomy (NAR) and perforation rates (21). The positive impact of the clinical and imaging evaluation has been shown in this study where out of 112 appendicectomies performed only 12 patients had normal appendices on histology giving an overall negative appendicectomy rate of 10.7% (table 5). This finding is similar to other studies which report a negative appendicectomy rate of 9.8% (16, 21, 22).

Whereas this study has found that the sensitivity, positive predictive value and accuracy of US for the diagnosis of acute appendicitis was high at 92%, 95% and 88.4% respectively (Table 5); it has also shown low specificity (58.3%) and negative predictive value (47%) rates. Similar findings have been reported elsewhere (23). Some of the reasons for the low specificity and NPV rates could relate to operator dependence as well as patient's habitus, excessive bowel gas, retrocecal or ectopic positioning of appendix which can reduce significantly the usefulness of ultrasound. Despite these challenges, many authors advocate for the use of ultrasound in the diagnosis of acute appendicitis (7, 15, 19, 20,22,23) and only recommend the use of other imaging modalities such as contrast enhanced abdominal CT scan or MRI in selected or equivocal cases (20, 25, 26). One clear and important advantage of pre-operative ultrasound in women with suspected acute appendicitis is the diagnosis of alternative gynecological conditions that can then be referred for appropriate management (20).

In conclusion this study has shown that ultrasonography by graded compression technique is a useful imaging study for the evaluation of acute appendicitis especially in clinically equivocal cases and in female patients where gynecological disorders are important mimics.

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