# Evaluation of the diagnostic yield of ultrasound in the management of appendicitis: An experience in a tertiary hospital in South-Eastern Nigeria

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**Abstract** Introduction: In most complaints of right lower abdominal pains appendicitis is suspected. Appendicitis often creates the most common abdominal surgical emergency. Ultrasound and computed tomography are often the imaging modalities used to confirm the clinical diagnosis of appendicitis. The aim of this study was to evaluate the accuracy of ultrasound in the diagnosis of appendicitis in a tertiary hospital in South Eastern, Nigeria.

**Materials and Methods:** A retrospective study design was adopted to study 152 records of patients aged 1–65 years who had ultrasound scans for clinical suspicion of appendicitis at a tertiary hospital in Anambra State, South Eastern Nigeria from 2016 to 2018. Patients' age, gender, and provisional diagnosis were obtained from the patients' request forms. Ultrasound results were obtained from the radiology department and the histology reports from the histology unit of the hospital. The Statistical Package for the Social Sciences, SPSS, version 22.0. was used for data analysis.

**Results:** Of the 152 cases, ultrasound was positive in 115, while histology confirmed 136 positives. Ultrasound, therefore, had a sensitivity, specificity, and accuracy of 84.56%, 100%, and 86.18%, respectively. The positive predictive value and negative predictive values were 100% and 43.24%, respectively. The study showed a higher incidence of appendicitis among females (n = 84) than males (n = 52), (ratio 1:1.6). Age groups 10–19 and 20–29 years were the most affected. Accuracy was 91.94% (in males) and 82.22% (in females). The most common ultrasound features include enlarged appendix (>9 mm, 100%), rebound tenderness to probe (92%), and fluid-filled appendix (88%).

Conclusions: Ultrasound has high sensitivity, specificity, and accuracy for the diagnosis of appendicitis.

Keywords: Appendicitis, diagnostic accuracy, sensitivity, tertiary hospital, ultrasound

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#### **INTRODUCTION**

The appendix is a small pouch-like sac of tissue with the length of 2–20 cm (average 9 cm) and base diameter about 6 mm, located in the posteromedial wall of the caecum about 2 cm below the ileocecal orifice in the right lower abdomen.<sup>[1,2]</sup> The position of its tip can however vary. It can be in the pelvis, outside the peritoneum, or behind the cecum and the prevalence of the positions varies amongst populations. The retrocecal position is most common among Ghana, (67.3%) and Sudan, (58.3%)<sup>[3,4]</sup> while the pelvic position is found more in Iran, (55.8%) and Bosnia, (57.7).<sup>[5,6]</sup> The vermiform appendix is the most variable abdominal organ in terms of position, extent, peritoneal, and organ relations.<sup>[7]</sup> Ethnic and geographical variations also exist.<sup>[8]</sup>

Appendicitis results from inflammation of the appendix and creates the most common abdominal surgical emergency with a lifetime incidence of 8.6% in males and 6.7% in females.<sup>[9]</sup> A major cause is obstruction of the lumen as a result of fibrous scar resulting from the replacement of lymphoid follicles by collagenous tissues that occur with age.<sup>[10]</sup> Acute appendicitis is a common gastrointestinal disease affecting 5.7–57/10,000 individuals each year, with the highest incidence in children and adolescents.<sup>[11]</sup> Acute appendicitis can affect any member of the population. It is often suspected in patients having right quadrant abdominal pains.

The incidence of acute appendicitis is said to be higher in developed than in developing countries. Ferris et al.[11] reported an annual incidence of 100/100,000 individuals for Northern America. The incidence in Nigeria is not certain because of the lack of comprehensive data. Ahmed et al.[12] reported an annual incidence of 2.6/100,000 individuals for Kaduna State in Northern Nigeria. Most researchers opine that the incidence is higher in males than females.<sup>[13-18]</sup> Without timely treatment there is a high likelihood of rupture leading to peritonitis with increased morbidity and mortality.<sup>[19,20]</sup> Early diagnosis is, therefore, imperative to obtaining proper management.<sup>[21,22]</sup> Ultrasonography, magnetic resonance imaging (MRI) and computed tomography (CT) scans are employed to augment clinical diagnosis of acute appendicitis. Both CT and MRI have higher sensitivity and specificity than ultrasound, but they are not easily available, are costly and CT makes use of ionizing radiation. Hence the choice of ultrasound.

Ultrasonography is a noninvasive and cheap diagnostic procedure using nonionizing radiation, that produces

real-time images which are used to assess the size, shape, and condition of the appendix in patients presenting with some clinical signs of the inflamed appendix. Graded-compression ultrasonography is used.<sup>[23]</sup> Rebound tenderness to the ultrasound probe often points to a positive diagnosis of acute and chronic appendicitis. The use of ultrasonography in the evaluation of patients clinically suspected of having appendicitis has been extensively reported in the literature but with great variability in the reported performance of ultrasonography for the diagnosis of appendicitis.<sup>[24]</sup> Despite the variability, many authors advocate ultrasound because of its unique nature of being noninvasive and nonuse of ionizing radiation. CT is however recommended when the ultrasound result is negative or inconclusive.<sup>[25,26]</sup> The use of computer-aided artificial intelligence - based techniques is also being advocated for the diagnosis of acute appendicitis.<sup>[25]</sup> Diagnostic sonographic features include free fluid collection in the right iliac fossa, noncompressible appendix mass (due to walled-off abscess), appendix surrounded by an echogenic mesenteric fat, acoustic shadowing indicating appendicolith, and increased blood flow on Doppler interrogation.<sup>[27]</sup>

The importance of ultrasound in the management of acute appendicitis lies in the fact that it not only makes the diagnosis of appendicitis but also helps in excluding other conditions which simulate acute appendicitis in clinical presentation but which management protocol is quite different from that of acute appendicitis. Some of these conditions include localized peritonitis due to distended small bowel loops with reduced peristalsis in the right iliac fossa, torted right ovarian cyst, right tubal ectopic gestation, right ovarian dermoid cyst, hemorrhagic ovarian cyst, right hydrosalpingitis, mesenteric adenitis due to inflamed enlarged right iliac lymph nodes, right vesicoureteric junction calculus, and many others. Accurate diagnosis is very imperative in these conditions, especially in teenage young females where poor diagnosis/management can lead to possible gynecological complications.

The aim of this study was to assess the diagnostic yield of ultrasonography in the management of appendicitis by determining its accuracy, sensitivity, and specificity.

# MATERIALS AND METHODS

A retrospective study design was adopted. The request forms of two hundred and fourteen (214) in-patients who had a history of right lower abdominal pains with suspicion of appendicitis and attended for ultrasound scan at the radiology department of the Teaching Hospital in Anambra State, Nigeria, during the period of the study (2016–2018) were retrieved. With the information on the request forms, the patients' folders were traced at the Medical Records Unit. One hundred and fifty-two of the patients were found to also have appendectomy at the hospital during the same period. These 152 patients were, therefore, retrospectively evaluated. Purposive sampling method was used for retrieving the patients' records based on the purpose of the study. The study lasted from March to May 2019.

Information on the age, gender, clinical history/provisional diagnosis, date of investigation, and ultrasound findings was obtained from the ultrasound reports of the patients in the Radiology Department. Surgical and histopathology (biopsy) data were obtained from patients' folders in the Medical Records Unit. The accuracy, sensitivity, specificity, positive predictive value (PPV), and negative predictive value (NPV) of ultrasound for the diagnosis of appendicitis were then computed based on the results. The equipment used was prosound ultrasound machine, model PF-5504SN: M00985 (a product of ALOKA Company Limited, Tokyo Japan) manufactured in 2008. It has a 3.5–5 MHz curvilinear probe and a 7.5–10 MHz linear probe. All scans were performed by qualified radiologists.

The computation of these values is done using Crocker *et al.*<sup>[28]</sup> formula:

- 1. Sensitivity = TP/TP + FN × 100. Where TP (true positive) = 115, FN (false negative) = 21
- 2. Specificity =  $TN/(TN + FP) \times 100$ . Where TN (true negative) = 16, FP (false positive) = 0
- 3. Accuracy =  $(TP + TN)/(TP + TN + FP + FN) \times 100$ . Where TP = 115, TN = 16, FP = 0, FN = 21
- 4.  $PPV = TP/TP + FP \times 100$ , where TP = 115 and FP = 0
  - Hence PPV =  $115/115 \times 100 = 100\%$
- 5. NPV = TN/TN + FN × 100, where TN = 16 and FN = 21. Hence PNV = 16/(16 + 21) ×100 = 43.24%.

Data analysis was done with computer software package (SPSS version 22.0; IBM Corp. Armonk, NY, USA, 2013) and results presented using frequency tables and percentages. Ethical approval for the study was obtained from the Ethical Committee of the institution before the commencement of the study. Permission was also obtained from the Head of the Radiology Department and also from the Head of the Medical Record Unit of the hospital.

## RESULTS

One hundred and fifty-two patient's cases consisting of 62 males and 90 females (male: female = 1:1.5) were

analyzed. The age ranged from 1 to 65 years with a mean of  $24.5 \pm 3.0$  years. Majority of them was in the 10–29 years age group [Table 1]. Ultrasound made positive diagnosis for appendicitis for 115 patients and negative diagnosis for 37 patients. Histology result confirmed 16 of the 37 patients which ultrasound reported as positive to be truly positive for appendicitis. Histology results confirmed 236 cases to be positive for appendicitis and 16 negative for appendicitis. All the 115 cases which ultrasound reported positive were also found to be positive by histology results. Twelve of the 21 cases which ultrasound reported as negative but which histology found to be positive were from the 20 to 49 years age group. Appendicitis was more in the 10–29 years age group (n = 85; 62.50%) and least in the 60 years and above age group (n = 5; 3.67%). This study also showed that the occurrence of appendicitis was higher in females (n = 84; 61.76%) than in males (n = 52; 38.24) (male: female = 1: 1.6) [Table 2]. Table 3a shows the ultrasound and histology results for comparison. Results also indicated that ultrasound has higher sensitivity and accuracy in males (90.38% and 91.94% respectively) than in females (80.95% and 82.22%, respectively) and equal specificity (100%) for both sexes. Sensitivity and accuracy were least in the 60 years and above age group [Table 3b]. Sonographic features used to diagnose appendicitis include enlargement of the appendix (> 9cm) which was seen in 100%, rebound tenderness to probe (92%) fluid-filled appendix (88%) periappendiceal fluid (80%) hyperechoic appendix (40%), and appendicolith (24%) [Table 4].

Age range (years)	Frequency (%)
Males	62 (40.79)
Female	90 (59.21)
Total	152 (100)
0-9	16 (10.53)
10-19	50 (32.89)
20-29	45 (29.61)
30-39	14 (9.21)
40-49	13 (8.55)
50-59	8 (5.26)
60 and above	5 (3.95)
Total	152 (100)

Table	1:1	Demographic	characteristics	of study	v subiects
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Table	2:	Sex	and	l age	distribution	of	subjects	diagnosed	of
appen	Idio	citis	on	scan					

Age range (years)	Frequency (%)
Males	52 (38.24)
Female	84 (61.76)
0-9	15 (11.03)
10-19	47 (34.56)
20-29	38 (27.94)
30-39	13 (9.56)
40-49	11 (8.09)
50-59	7 (5.15)
60 and above	5 (3.67)
Total	136 (100)

#### DISCUSSION

The result of this study showed that appendicitis is more prevalent in females than in males and that the diagnostic sensitivity and accuracy of ultrasound was more in males than in females. This agrees with findings made by<sup>[29,30]</sup> in Iran and Ahmed et al.<sup>[12]</sup> in Northern Nigeria but contrary to a study in South-Western Nigeria which reported the incidence more in males.<sup>[9]</sup> The results from this study also showed that the occurrence of appendicitis was more in the 10-29 years age group. This contradicts a study<sup>[10]</sup> which said appendicitis results from filling of the appendix with the fibrous scar as a result of the replacement of lymphoid follicles by collagenous tissues that occur with age. Going by that statement appendicitis should be expected to be higher in the 50-60 years and above. Results from our study rather agreed with the results from a study which held that acute appendicitis occurs most commonly in the second and third decades of life.<sup>[31]</sup> From the hypothesis about the etiology of appendicitis, this may be due to the alimentary canal of these young ones not being able to break down the raw plants chewed, and seeds of fruits swallowed. These can lodge in the appendix, leading to primary obstruction of the appendix resulting in appendicitis. As seen from this study appendicitis was more in the females contrary to findings by Oguntola et al.<sup>[9]</sup> The higher incidence in females may be as a result of the difference in the diet as diet is said to be a factor. In general, men are said to consume more

Table 3a: Ultrasound and histology results of appendicitis cases

Age groups	Ultr	asoun	d	Histology			
(years)	Frequency	Male	Female	Frequency	Male	Female	
1-9	12	7	5	15	8	7	
10-19	44	18	26	47	18	29	
20-29	32	9	23	38	11	27	
30-39	10	6	4	13	7	6	
40-49	8	3	5	11	3	8	
50-59	6	1	5	7	2	5	
60 and above	3	3	0	5	3	2	
Total	115	47	68	136	52	84	

fiber diets than females and fiber diets are said to reduce fecal transit time which in turn reduces the probability of appendicitis.<sup>[32-34]</sup>

With the knowledge of the presenting symptoms of acute appendicitis and its relationship with age and gender and that the noninvasive, cheap, and easily available ultrasound scan can diagnose it patients are more likely to present to the hospital early thereby reducing the rate of morbidity and mortality from the disease.

Ultrasound made the accurate diagnosis in 131 (86.18%) with sensitivity, specificity, PPV, and NPV of 84.56%, 100%, 100%, and 43.24%, respectively. The higher sensitivity and accuracy in males may be because the average size of the appendix is more in males than in females.<sup>[10]</sup> This, coupled with the fact that in males the location of the appendix is mainly retrocecal or pelvic, while in females the location is mainly subileal<sup>[8]</sup> may, therefore, makes it easier to identify inflamed appendix in males. These results showed that ultrasound can be relied upon in the diagnosis of appendicitis and thus reduce negative appendectomy rates (NARs) to the minimum. The high accuracy of ultrasound in the diagnosis of appendicitis in the 10-29 years age group proves its usefulness as negative appendectomy in this group may have some serious gynecological complications, especially in females. The findings from this study agree with the results obtained in Iran<sup>[30]</sup> and in the UK.<sup>[31]</sup> Findings from this work, however, disagreed with the work by<sup>[32]</sup> in the UK which reported that ultrasound failed to visualize 45% of appendicitis and has sensitivity of 51.8% and specificity of 81.4%. The slight difference in the sensitivity and accuracy values obtained in this study and the result obtained in a study in Iran<sup>[30]</sup> may be due to differences in the equipment and experience of the radiologists/sonographers since many radiologists/sonographers independently performed the ultrasound scans. Experience may also be the cause of the difference in the results obtained by Sheikh<sup>[35,36]</sup> in the

Table 3b: Sensi	tivity, specificity	/ and accuracy	values for age	and gender for	or ultrasound in	diagnosis of	f appendicitis
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Patients characteristics	Number of patients	Sensitivity (TP/FP+FN) (%)	Specificity (TN/TN+FP) (%)	PPV (TP/ TP+FP) (%)	NPV (TN/ TN+FN) (%)	Accuracy (TP+TN/ total) (%)
Male	62	90.38 (47/52)	100 (10/10)	100 (47/47)	66.67 (10/15)	91.94 (57/62)
Female	90	80.95 (68/84)	100 (6/6)	100 (68/68)	27.27 (6/22)	82.22 (74/90)
Total	152	84.56 (115/136)	100 (16/16)	100 (115/115)	43.24 (16/37)	86.18 (131/152)
1-9 years	16	80.00 (12/15)	100 (1/1)	100 (12/12)	25 (1/4)	81.25 (13/16)
10-19 years	50	93.62 (44/47)	100 (3/3)	100 (44/44)	50 (3/6)	94.00 (47/50)
20-29 years	45	84.21 (32/38)	100 (7/7)	100 (32/32)	53.85 (7/13)	86.67 (39/45)
30-39 years	14	76.92 (10/13)	100 (1/1)	100 (10/10)	25 (1/4)	78.57 (11/14)
40-49 years	13	72.73 (8/11)	100(2/2)	100 (8/8)	40 (2/5)	92.31 (12/13)
50-59 years	8	85.71 (6/7)	100 (1/1)	100 (6/6)	50 (1/2)	87.50 (7/8)
60+years	6	60 (3/5)	100 (1/1)	100 (3/3)	33.33 (1/3)	66.67 (4/6)

Total - TP+FP+TN+FN. TP - True positive; FP - False positive; TN - True negative; FN - False negative

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Table 4: Sonographic diagnosttic	features of appendicitis	
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Sonographic findings	Nonperforated (%)	Perforated (%
Enlarged appendix >9 cm	100	40
Rebound tenderness to probe	92	40
Periappendiceal fluid	0	80
Fluid filled appendix	88	40
Appendicolith	24	20
Hyperechoic appendix	40	50

same UK population. Some authors<sup>[33,37]</sup> preferred the use of CT, CT and MRI, MRI with a sensitivity of 96%–100% and 91%–100% respectively to ultrasound with a sensitivity of 85% and specificity of 90%. However, considering the availability and cost of MRI and the radiation exposure associated with CT, one may prefer ultrasound as the first-line diagnostic tool for appendicitis.

The common diagnostic sonographic features of appendicitis seen in this study include enlarged appendix (>9 mm), hypoechoic fluid-filled appendix, and rebound tenderness at right lower abdomen/right iliac fossa (McBurney's point), periappendiceal fluid-indicative of the perforated (leaking) appendix and presence of faecaliths. These results are in agreement with the works which opined that the common sonographic features of appendicitis are an enlarged appendix and a fluid-filled appendix that for a nonperforate appendicitis, the only definite sonographic feature is enlarged appendix while for perforated appendicitis, the presence of loculated pericecal fluid is a definite sonographic feature.<sup>[27,38]</sup> However, another study<sup>[39]</sup> said that the tendency to equate an enlarged appendix with appendicitis is shown to lead to an inappropriate diagnosis and jeopardize the optimal care of patients with acute abdominal pain.

# CONCLUSIONS

From our study, in our locality, appendicitis affects people in the 10–29 years age group most. The incidence is higher in females than in males but ultrasound diagnosis of appendicitis is more accurate in males than in females. Ultrasound has high sensitivity, specificity, accuracy, and PPVs for the diagnosis of appendicitis. The main diagnostic ultrasound features are enlarged, fluid-filled appendix and loculated pericecal-in cases where there is perforation.

The use of ultrasound in the diagnosis of suspected appendicitis can reduce NARs. Therefore, in a resource-constraint environment like Nigeria ultrasound can reliably be used for the diagnosis of appendicitis. Apart from the advantage of availability and reduced cost, it also saves patients from the harmful effects of ionizing radiation that can occur with the use of CT. A multicentre study taking into account the socioeconomic status of patients is necessary to obtain the incidence of the disease in the state.

## Limitations of the study

- 1. The study was based on only one hospital which made it impossible to estimate the incidence of appendicitis in the state or even Nnewi city
- 2. The study is a retrospective one, so it was not possible to get information on the socio-economic status of the patients which would have helped to know the class of people most affected by the disease
- 3. No sonograms were attached to the ultrasound reports to enable researchers to know which of the ultrasound probes was used. This would have helped to know which probe is more suitable for particular patients.

# Areas for further studies

Researchers recommend a multi-center study that will also cover a longer period and which will take into consideration the socio-economic status of patients. This will help in determining the incidence of the disease in the state.

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## **Conflicts of interest**

There are no conflicts of interest.

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