ORIGINAL ARTICLE

Value of Ultrasonography in Diagnosis of Acute Appendicitis: A Cross-Sectional Prospective Study

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ABSTRACT

Background: Abdominal ultrasonography is an essential imaging modality in diagnosing patients with acute appendicitis. Its major advantages include high diagnostic accuracy, availability, affordability, and excellent safety profile relative to other imaging modalities with few limitations in children. Clinical diagnosis of acute appendicitis and the modified Alvarado scoring system (MASS) have good sensitivity, but low specificity. **Methods:** This was a prospective comparative study at Federal Teaching Hospital, Abakaliki which lasted for 1 year and eight months from April 2018 to December 2019 which involved 50 patients with clinical presentations of acute appendicitis who were evaluated clinically using the MASS and by ultrasonography before surgical treatment and final diagnosis with histology. The following were recorded for data analyses: socio-demographic data, clinical features and laboratory findings (modified Alvarado Score), ultrasonographic score, clinical diagnosis, and final (histological) diagnosis. The data were analyzed using a statistical package for social sciences for Windows version 22 (IBM, USA, 2015). **Results:** The age of the participants ranged from 4-70 years with a mean age of 31.5±17.2 years. The majority of the participants, 39 (78%) patients were within 31-40 years. The gender distribution showed that more males-29 (58%) than females-21 (42%) participated in the study. The sensitivity, specificity, and diagnostic accuracy of ultrasonography were 95.5%, 83.3%, and 94% respectively which were significantly better than the corresponding indices of modified Alvarado score: 86.4%, 44.4%, and 84% respectively. The optimum (cut-off) ultrasonographic score of 3.75 yielded sensitivity and specificity of 95.5% and 100% respectively. Combined ultrasonographic and modified Alvarado score of 11.75 (optimum score) yielded a sensitivity of 84.1% and a specificity of 100% in diagnosing acute appendicitis. **Conclusion:** Ultrasonography has a high diagnostic yield in the evaluation of acute appendicitis and should be adopted as the modality of choice in our environment. Ultrasonographic scoring system improved the diagnostic yields of ultrasonography and should be incorporated as a tool in the ultrasonographic evaluation of patients with acute appendicitis. More importantly, the surgical specimens should be submitted for a definitive histopathology examination.

Keywords: Ultrasonography, Diagnostic accuracy, Acute appendicitis

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Introduction

Acute appendicitis is the inflammation of the vermiform appendix.[1] It is the most common cause of acute abdominal pain worldwide.[2] The clinical scoring

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system and ultrasonographic scanning are popular for the diagnosis of acute appendicitis. These modalities are used alone or in combination to make a diagnosis of acute appendicitis. The clinical diagnosis of acute appendicitis is made through the use of a modified Alvarado scoring system (MASS). The components of the scoring system include history (to obtain the symptoms), clinical examination (to elicit signs), and laboratory investigation (full blood count to demonstrate leucocytosis/neutrophilia). The modified Alvarado Scoring system has been associated with mixed results.[1,3] Ultrasonography is a good imaging modality but has limitations which include operator dependence, resolving power of the machine, and patient factors like obesity and retrocaecal location of the appendix.[1] Laboratory investigations like full blood count and C-reactive protein assay are sensitive but not specific. Therefore, the diagnosis of acute appendicitis has always posed a challenge to both the emergency room physicians and the surgeons who want to make quick decision to avoid complications and as well reduce the rate of negative appendectomies.[3]

There is a wide range of differences in geographical distribution of the incidence of acute appendicitis. The lifetime incidence of acute appendicitis is 16% among Koreans, 7-9% in the United States of America, and 5-8% in the United Kingdom.[4] However, the incidence among Africans is 1.8%.[5] A study in South-Western Nigeria by Oguntola et al documented an incident rate of 1.86% with acute appendicitis responsible for about 10% of the cases of acute abdomen.[5] This was similar to a review in a Ghanaian study by Ohene-Yeboah and colleagues.[5]

There are numerous differential diagnoses of acute appendicitis especially in females of reproductive age such as ovarian cyst torsion, ectopic pregnancy, and salpingitis due to pelvic inflammatory diseases.

The pathogenesis of acute appendicitis is through luminal obstruction (with faecoliths, lymphoid hyperplasia, impacted stool, swallowed seeds, and rarely appendiceal or caecal tumour) and subsequent vascular thrombosis.[8]

The exact aetiology of acute appendicitis is not known and is believed to be idiopathic. The associated risk factors include pelvic infection, family history, and environmental factors.[9] Environmental influence was also reported in a study in Nigeria by Oguntola et al who reported an increased incidence during the rainy season.[6]

Clinical evaluation of acute appendicitis is done by the use of the Alvarado scoring system (ASS) and recently by the MASS. This system incorporates, three clinical symptoms (migrating pain to the right lower quadrant, anorexia, nausea/vomiting), three signs (tenderness in the right lower quadrant, rebound tenderness, elevation of temperature), and one laboratory finding (leucocytosis > 10,000/L). The minimum and maximum scores obtainable are zero and nine (9) respectively.[3]

The use of ultrasonography as a diagnostic tool for the diagnosis of acute appendicitis was made popular by Puylaert (1986) - using his technique of graded compression of the right lower abdomen and meticulous demonstration of both the direct and indirect ultrasonographic signs of acute appendicitis.[3,7] Imaging evaluation is often necessary to resolve the diagnosis. It also facilitates early intervention in positive cases, with the potential to reduce complications resulting from delay in diagnosis. On the other hand, unnecessary surgical interventions are also averted in negative cases.[2]

Ultrasound is a high-frequency sound wave beyond the audibility of the human ear (usually above 20 kHz). This imaging modality is readily available, has no risk of ionizing radiation, and is cost-effective.

Ultrasound evaluation of the abdomen in acutely painful conditions has gained acceptance as an imaging modality of choice in emergency settings and in selecting patients who may require urgent surgical intervention, therefore, reducing the rate of negative laparotomies.[11]

The ultrasonographic features of acute appendicitis described by Puylaert et al formed the basis for the ultrasonographic scoring system used in this work.[7] These include right iliac sonotenderness, appendiceal diameter greater than 6 mm, demonstration of aperistaltic non-compressible appendix, echogenic fat around the appendix, increased colour Doppler flow, peri-appendiceal fluid and peri-appendiceal lymph node enlargement.[7]

A recent study at Federal Teaching Hospital, Abakaliki revealed a high negative appendicectomy rate of 22.7%- increasing to 40% in women of childbearing age.[12] This is far higher than the 4.6 % documented in another older study in Maiduguri, Nigeria.[13]

This study aimed to evaluate patients with clinical symptoms and signs of acute appendicitis using clinical scoring (modified Alvarado score) and

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ultrasonography, to make diagnosis of acute appendicitis and compare with the final (histopathologic) diagnosis and to determine and compare the sensitivity, specificity, and diagnostic accuracy of both clinical scoring and ultrasonography in the diagnosis of acute appendicitis.

Methods

Study Design: This was a prospective comparative study in which 50 patients with clinical presentations of acute appendicitis were evaluated clinically (modified Alvarado scoring system) and also by ultrasonography before surgical treatment and final diagnosis by histology. Ultrasonography and modified Alvarado scores were compared with the final (histology) diagnoses to obtain the diagnostic performance markers for each of the ultrasonography and modified Alvarado scores. The ultrasonographic signs demonstrated were also used to formulate a scoring system for acute appendicitis. The study duration was one (1) year and eight (8) months -with effect from April 2018 to December 2019 at Federal Teaching Hospital, Abakaliki, South-eastern Nigeria.

Study Population

Volunteers were consecutively recruited from patients with provisional clinical diagnosis of acute appendicitis and referred to the Ultrasonography unit of the Radiology Department for imaging. Informed consents were duly obtained from the patients or caregivers.

Sampling Method: Participants were recruited consecutively from the patients with clinical suspicion of acute appendicitis, acute right lower abdominal pain, and acute abdomen of unknown cause referred to the Ultrasonography unit of the Radiology Department from the Accident and Emergency unit of the hospital. Patients on admission to the wards who developed acute abdomen with clinical symptoms and signs of acute appendicitis- were also included.

Sample Size Determination

This was calculated from Fisher's formula when the population is greater than 10,000 in size.[30]

$$Ns = (Z/E)^2(P)(1-P)$$

Where:

Ns = required sample size

Z = standard score corresponding to a given confidence limit

E=Error margin

P = Estimated proportion or incidence of cases in a given population.

A confidence limit of 95% with a tolerable error margin of not greater than + or – 0.05 was desired. This gave a standard score of 1.96. The estimated incidence of cases of acute appendicitis in Nigeria is approximately 1.8% .[6]

Hence, the appropriate sample was calculated thus:

$Ns = (1.96/0.05)^2 (0.018) (1-0.018)$

$Ns = (39.2)^2 (0.018) (0.982) = 27.2$

A sample size of 50 was chosen to increase the precision.

Inclusion Criteria:

1) Patients with the clinical diagnosis of acute appendicitis.
2) Patients with acute right lower abdominal pain are referred to the ultrasonography unit of the Radiology Department.
3) Patients with acute abdomen of doubtful diagnosis.
4) Patients who developed clinical symptoms and signs of acute appendicitis in the wards.

Exclusion Criteria:

1) Patients who were clinically not stable to undergo the procedure.

2) Non consenting patients.

3) Patients with a recent history of abdominal trauma.

4) Patients with incomplete data

5) Women with right lower abdominal pain due to gynaecological causes

6) Patients whose appendix could not be visualized on ultrasound scan

Equipment

This study was carried out using Accuvix A30 (Medison LV, Korea, 2013) ultrasonography machine fitted with curvilinear (3.5 – 5 MHz) and linear (7.5 -

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10 MHz) transducers. The machine also has Doppler and 3D capabilities.

Sonographic Findings

The sonographic abnormal findings included sonotenderness of the right lower abdomen, peri-appendiceal fluid collection, change in echopattern of the appendix wall, change in the motility of the bowel around the appendix, vascular flow abnormalities, increased fat stripling (echogenicity) around the appendix, the enlarged diameter of the appendix and increased wall thickness. All measurements were recorded by averaging three measurements to reduce the rate of false positive/negative due to overestimation/underestimation of wall thickness, or diameter of the appendix.

The positive findings in acute appendicitis were grouped into direct and indirect findings. The direct findings were: demonstration of non-compressible aperistaltic appendix, maximum outer diameter (MOD) greater than 6 mm, single wall thickness of more than 2 mm, targetoid appearance in transverse view, abnormal colour Doppler flow (increased flow in acute appendicitis or reduced flow in necrotic/gangrenous appendix), presence of appendicolith and irregular/discontinuity of the appendix wall in cases of a ruptured appendix. Other indirect positive findings include right iliac fossa sonotenderness, hyperechogenicity of the surrounding fat, free peri-appendiceal fluid, local abscess formation in the right iliac fossa, hypoperistalsis of bowel loops in the right iliac fossa, peri-appendiceal lymphadenopathy. A score of one (1) was assigned to every direct ultrasonographic positive finding elicited whereas half score (1/2) was assigned to every indirect finding elicited. A maximum score of nine (9) was obtained by summation of all the scores.

Modified Alvarado scores (MAS) ≥ 7 were taken as positive diagnosis for acute appendicitis based on the works of Bassem et al and Koller et al.[14,15] The scores from clinical and laboratory findings include: migrating pain to the right lower abdomen, anorexia, nausea/vomiting, tenderness of the right lower abdomen, rebound tenderness, elevated temperature, and leucocytosis. Tenderness of the right lower quadrant and leucocytosis scored two (2) each. The rest of the clinical findings scored one (1) each giving a total score of nine (9). The patients' full blood count (FBC) results were extracted from the patient's folder. The white blood cell count (WBC) was recorded; WBC was considered to be increased (leucocytosis) if > 10,000/L.

The patients were followed up with surgery and the operative techniques include: anaesthetic preparation, Lanz incision with muscle splitting access, mobilization with clamping and ligation of the base of the appendix, and sutural closure done in layers. Complicated cases like perforated appendix were operated upon through midline incision; while appendiceal masses were treated by interval appendectomy. The hospital policy stipulate that all specimens excised during surgical operations were sent to the histopathology for analysis and final diagnosis.

The specimens of the appendix removed during operative treatment were preserved in 10% neutral buffered formalin solution and taken to the histopathology laboratory. The final diagnoses were established by consultant anatomic pathologist as shown in Figure 1C

Techniques

The researcher conducted this study under the supervision of a consultant radiologist. All the selected patients signed an informed consent form. The patients were made to lie comfortably on the couch, brief histories of the patient's symptoms were obtained, and pain was characterized. The researcher performed focused physical examinations following standard protocols, and the modified Alvarado Scores (MAS) were assigned based on clinical and laboratory findings.

The longitudinal and transverse scanning of the abdominal organs: liver, gallbladder, spleen, pancreas, aorta, kidneys, and pelvic viscera were evaluated to check for other differential diagnoses of acute abdominal pain.

The transducers were placed in transverse position starting from the right upper abdomen through the McBurney's point, and scanning inferiorly along the gas-filled ascending colon down to the ileocaecal valve. The transducers (probes) were maintained along the same plane while scanning caudally towards the caecal end which marked the termination of the gas-filled large bowel loops on the right iliac fossa. These terminal points were related to the psoas muscles posteriorly and inferiorly to the hypoechoic tubular structures-the femoral vessels. Colour Doppler scan was used to confirm the flow within the vessels and used as a landmark in ultrasonography of

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the appendix. A careful search and slower scanning speed were maintained until the vermiform appendix was identified as compressible, peristaltic, blind-ending tubular structures with maximum outer diameter > 6 mm. The transducer was then turned through 90 degrees to get the longitudinal view of the appendix, further demonstrate the blind-ending tubular structures, check the appendiceal lumen for concretions (appendicolith), and rule out segmental appendicitis.

The graded compression technique was also used to evaluate the right lower abdomen for signs of acute appendicitis and other pathologies. In graded compression technique, a linear transducer was used to apply pressure gradually to the right lower quadrant to displace the bowel and their contents. Adequate compression was deemed to be achieved when the psoas muscles and the iliac vessels were demonstrated. The pressure was maintained at that level while the outline of the caecum (identified by its gaseous contents and large lumen) was followed inferiorly to locate the appendix at converging point of the taenia coli which was located close to the caecal tip (the caecal tip was taken as a pointer to the converging point for the taenia coli, in ultrasonography, since the taenia were difficult to demonstrate). In retrocaecal appendix, the patients were turned slightly to the left to displace the gassy caecum and enhance the demonstration of the appendix. Full urinary bladder was also used as acoustic window -especially in pelvic appendix.

The measurement of appendiceal diameter was taken as the maximum outer wall diameter (MOD). The wall thickness was measured from the inner mucosal layer to the adjacent outer wall as demonstrated in Figure 1(A and B) for the MOD and wall thickness. Measurements were repeated three times and average recorded. The entirety of the appendix was demonstrated in the scans- in order to reduce false negative due to segmental appendicitis. The curvilinear probe was used in obese patient for better depth resolution. Colour Doppler scans were also used to ascertain the vascularity of the demonstrated appendix. Inflamed appendix usually shows increased vascular flow as shown in Figure 1A, while necrotic/gangrenous appendicitis shows reduced or absence of colour flow on the wall.[3] In addition, histology section of the appendix shows infiltration of the muscularis propria with neutrophils as illustrated in figure 1C.

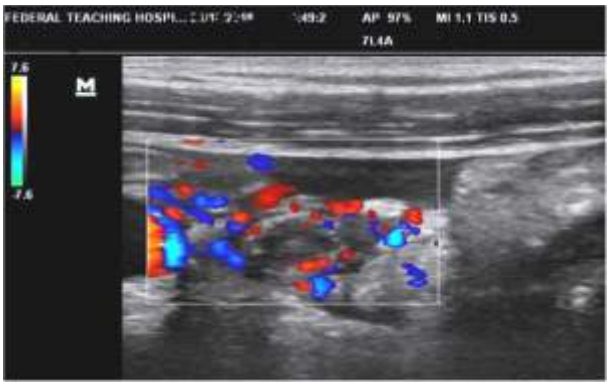

Figure 1A: Transverse duplex sonographic image of an inflammed appendix which shows increased flow within and around the appendix.

Figure 1B. Gray-scale ultrasonographic image showing a longitudinal of an inflamed appendix with non-compressible enlarged appendiceal diameter (callipers), thickened wall with calcifications, and peri-appendiceal echogenic fat in a patient with acute appendicitis

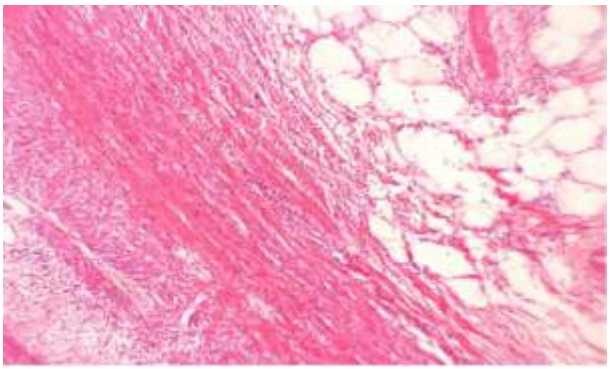

Figure 1CX 400Mag: Histologic section of appendix showing infiltration of the muscularis propria with neutrophils which is consistent with acute appendicitis.

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Data Analysis

The data were analyzed using statistical package for social sciences (SPSS) for Windows version 22 (IBM, USA, 2015). Tables and charts were used to summarise results. Statistical tests were considered significant at p-value ≤ 0.05. Descriptive statistics which include frequency, percentage, mean and standard deviation were used to summarize the data. Both diagnoses obtained by modified Alvarado score and ultrasonographic diagnosis were correlated with histopathologic diagnoses to obtain the sensitivity, specificity, positive predictive value, negative predictive value, and diagnostic accuracy for each of the scores.

Ethical Consideration

The ethical clearance was obtained from the health research and ethical committee of the Federal Teaching Hospital, Abakaliki with registration number FETHA/REC/VOL1/2017/624.

Results

A total of 50 patients were recruited for the study which lasted for 1 year and eight months - from April 2018 to December 2019. Table 1 revealed that age, gender, and body mass index (BMI) had no significant relationship with Modified Alvarado score in diagnosis of acute appendicitis as reflected in their respective p-values-which were > 0.05. The p-values in age, gender, and body mass index revealed that no significant relationship exists between these variables and ultrasonographic diagnosis of appendicitis (Table 2).

Table 3 revealed that non-compressible aperistaltic appendix, targetoid appearance, appendiceal diameter > 6 mm, and single wall thickness greater than 2 mm were the most common direct signs elicited. The least common was appendicolith which occurred in 5 (10%) patients. The most common indirect sign demonstrated was right iliac fossa tenderness which occurred in all the 50 (100%) patients. This was followed by echogenic fat stripling seen in 44 (88%) patients while the least frequent was lymphadenopathy noted in 19 (38%) patients.

The diagnostic markers: sensitivity, specificity, positive predictive value, negative predictive value, and diagnostic accuracy were determined for MAS and Ultrasound diagnosis; the table compares them to determine if the differences between the markers are statistically significant. The table shows that Clinical diagnoses of appendicitis using Modified Alvarado Scoring system show very good sensitivity, positive predictive value, and diagnostic accuracy but poor specificity and negative predictive value. Ultrasonographic evaluation showed excellent sensitivity, positive predictive value and diagnostic accuracy. In addition, ultrasound showed very good specificity and negative predictive value. The difference between the diagnostic markers across the modalities are statistically significant- as shown on Table 6.

Determination of diagnostic performance markers for modified Alvarado Score is illustrated below:

a. Sensitivity 86.4%

b. Specificity 44.4%

c. Positive predictive value (PPV) of the test 88.4%

d. Negative predictive value (NPV) of the test 57.1%

e. Accuracy84%

Determination of diagnostic performance markers for Ultrasonography as shown below.

(a) Sensitivity was 95.5%.

(b) Specificity was 83.3%.

(c) Positive predictive value (PPV) of Ultrasonographic diagnosis was 97.7%.

(d) Negative predictive value (NPV) of Ultrasonographic test was 71.4%

(e) Accuracy=TP+TN/(TP+TN+FP+FN) was 94%

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Table 1: Diagnosis of Acute Appendicitis Using Modified Alvarado Scoring System (MAS) in Patients with Suspected Acute Appendicitis According to Socio-demographic Characteristics.

Variable	MAS positive N (%)	MAS negative N (%)	p-value
Age group (years)			
≤40	34(87.2)	5(12.8)	0.654
>40	9(81.8)	2(18.2)	0.641
Total	43(86.0)	7(14.0)	0.487
Gender			
Male	26(89.7)	3(10.3)	0.381
Female	17(81.0)	4(19.0)	0.385
Total	43(86.0)	7(14.0)	0.319
Body mass index			
≤24.9	35(85.4)	6(14.6)	0.783
> 25	8(88.9)	1(11.1)	0.777
Total	43(86.0)	7(14.0)	0.630

p ≤ 0.05 is significant

Table 2: Diagnosis of patients with acute appendicitis using ultrasonography according to their socio-demographic characteristics.

Variable	USS positive N (%)	USS negative N (%)	p-value
Age group (years)			
≤40	34(87.2)	5(12.8)	0.651
>40	9(81.8)	2(18.2)	0.641
Total	43(86.0)	7(14.0)	0.487
Sex			
Male	27(93.1)	2(6.9)	0.089
Female	16(76.2)	5(23.8)	0.092
Total	43(86.0)	7(14.0)	0.115
Body mass index			
≤24.9	34(82.9)	7(17.1)	0.181
>25.0	9 (100)	0(0.0)	0.325
Total	43(86.0)	7(14.0)	0.225

P ≤ 0.05 is significant. USS: Ultrasonography

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Table 3: Distribution of Ultrasonographic signs of acute appendicitis.

S/no	Variable	Frequency	Percent (%)
	Direct Sign		
1	Non- compressible aperistaltic appendix	39	78
2	Diameter of the appendix > 6 mm	38	76
3	Single wall thickness > 2 mm	38	76
4	Target appearance in transverse view	39	78
5	Appendicolith	5	10
6	Abnormal flow in colour Doppler	34	68
	Indirect Sign		
1	Right iliac fossa sonotenderness	50	100
2	Mesenteric fat stripling at the RLQ	44	88
3	Free peri-appendiceal fluid	38	76
4	Local abscess formation at RLQ	25	50
5	Hypoperistalsis of RLQ bowel loops	26	52
6	Lymphadenopathy within RLQ	19	38

RLQ (Right lower quadrant)

Table 4: Determination of the diagnostic performance markers for Modified Alvarado Score

	Histopathologic diagnosis		
MAS diagnosis	**Positive**	**Negative**	Total
Positive	True positive	False positive	
	38	5	43
Negative	False-negative	True negative	
	3	4	7
Total	41	9	50

Table 5: Determination of diagnostic performance markers for Ultrasonography

	Histopathologic diagnosis		
Ultrasonographic diagnosis	**Positive**	**Negative**	Total
Positive	True positive	False positive	
	42	1	43
Negative	False negative	True negative	
	2	5	**7**
Total	44	6	50

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Table 6: Comparison of diagnostic performance markers of Ultrasonography (USS) with modified Alvarado scores (MAS).

Diagnostic Markers	MAS Markers	USS Markers	p-value
Sensitivity (%)	86.4	95.5	< 0.0001
Specificity (%)	44.4	83.3	< 0.0001
Positive predictive value (%)	88.4	97.7	< 0.0001
Negative Predictive Value (%)	57.1	71.4	0.0034
Diagnostic Accuracy (%)	84.0	94.0	< 0.0001

Discussion

The diagnosis of acute appendicitis using modified Alvarado scores, and ultrasonography showed no statistically significant relationship with age, sex, and BMI in this study, this is similar to the study of Asaleye *et al*.[16] However, Anderson *et al* documented a significant relationship with gender which is at variant with the present study. This could be due to the inclusion of gynaecologic causes of right iliac fossa pain by Anderson *et al* in their study.[17]

Ultrasonographic findings in acute appendicitis formed the crux of the appendiceal scoring system (Table 3). The distribution of the findings revealed: a non-compressible aperistaltic appendix in 78% of the patients, diameter > 6 mm in 76%, target sign in 78%, probe tenderness in 100%, free fluid in 76%, mesenteric fat stripling in 88%, and appendicolith in 10% of the patients evaluated. These findings were consistent with those of Ashaolu *et al* in OAUTH, Ife, South-western Nigeria, and Subash *et al* in Nepal.[18,19]

Diagnostic performance markers of the modified Alvarado scoring system, in the present study, showed that sensitivity, specificity, positive predictive value, negative predictive value, and diagnostic accuracy were 86.4%, 44.4%, 88.4%, 57.1%, and 84.1% respectively. Peyvasteh *et al* also documented similar values and concluded that the Alvarado score has high sensitivity, positive predictive value, but low specificity, and negative predictive value.[17] There were previous studies with a lower sensitivity of about 54% or less, but others[19] documented higher figures of 87%, 66%, 87%, and 66% for sensitivity, specificity, positive predictive value, and negative predictive value respectively.[20] The similarities between the present study and the reviewed studies may be explained by the practical applicability of the modified Alvarado score in diagnosing of acute appendicitis in clinical settings. However, the subtle differences noted between the cited works and the present study may be due to the subjectivity of some of the criteria used in the Modified Alvarado scoring system. For instance, pain is one of the criteria in the modified Alvarado scoring system which is a subjective assessment as different individuals perceive and respond to pain differently.

In all the previous studies, modified Alvarado proved to be a good diagnostic tool in acute appendicitis diagnosis. However, due to its low specificity and negative predictive value, it is not advisable to use it as a stand-alone diagnostic modality hence the need for combination with imaging.

The diagnostic indices of ultrasonography were also evaluated by comparing with histopathology diagnosis as the gold standard. This study's results of diagnostic performance were similar to the findings in the work of Ashaolu *et al* and concordant with other findings.[18,23] The results in the present study also compared favourably with the work of Asaleye and colleagues. However, Asaleye's work revealed lower values.[16] These differences could be attributed to inter-observer errors as Asaleye *et al* conducted a retrospective study in which ultrasonographic diagnoses were made by different operators. Subash and co-workers in Nepal, documented similar sensitivity, specificity, positive predictive value,

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negative predictive value, and diagnostic accuracy to our study.[24] The findings in the present study differed from the diagnostic accuracy of 24.4% obtained in a retrospective study in Zaria, North-western Nigeria by Garba *et al*.[25] The extremely low value of diagnostic accuracy in Garba study, may be due to the: usage of substandard ultrasonography machine and transducers and poor medical history to guide the operators, especially among self-referral patients. These limitations could be the reasons for the low diagnostic accuracy documented in their study.

Study Limitations

1. Pain is a major limitation in this study as adequately graded compression was required in order to evaluate the right lower quadrant.
2. Obese patients were generally harder to scan due to fat deposition and soft tissue bulk.

Attempts made to minimize these limitations include keeping the probe steady at the point of adequate compression and searching carefully for the appendix. This helped to minimize pain associated with the movement of the probes. Some patients were scanned with curvilinear (lower frequency) probes to achieve better depth penetration-especially in obese patients.

Conclusion

Ultrasonographic diagnosis of acute appendicitis showed a significant correlation with histopathological diagnosis with high sensitivity, specificity, and diagnostic accuracy. Also, the comparison of the diagnostic accuracies showed that the diagnostic accuracy (98.7%) of the ultrasonographic score alone was significantly better than the combined diagnostic accuracy (92.2%) of ultrasonography and modified Alvarado scores. Ultrasonographic evaluation showed significantly high diagnostic yields which were better than those of the modified Alvarado scoring system in the diagnosis of acute appendicitis.

Conflict of Interest Statement

The authors declared they do not have anything to disclose regarding the conflict of interest in this manuscript

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