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## Research Article

# Interobserver Variability in Ultrasound Scan Interpretation for Suspected Acute Appendicitis: a Cross-Sectional Cohort Study -

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## ABSTRACT

**Background:** There is a global resolve among Clinicians towards adoption of imaging modalities in the evaluation of appendicitis because clinical algorithms have been disappointing. We sought to determine the authenticity of interobserver variability in ultrasound scan interpretation in a resource-constrained mission hospital settings, northwestern region of Cameroon.

**Methods:** In this study, we reviewed the standardized diagnostic approach in acute appendicitis and also performed prospective cross observational qualitative testing using sensitivity, specificity, positive predictive value, negative predictive value, and accuracy to determine the interobserver variability of ultrasonography using the medical database of the two Mission Hospitals, northwestern region of Cameroon from January 2012 to December 2016. A sequential non-randomized convenient sampling was used and data was analyzed using the Statistical Package for the Social Sciences version 22.

**Results:** A total of 103 patients who had pre-operative evaluation with Ultrasound scan and subsequently underwent surgery with histo-pathological examination of the removed appendix were analyzed. Their ages ranged from 15 to 65 years with a mean age of  $30.6 \pm 18$ . There were 62 males and 41 females with a ratio of 1.5:1. Of the 103 patients, (n = 90; 87.4%) cases were diagnosed as AA by histopathology while (n = 9; 8.7%) cases were negative. Ultrasound was positive in (n = 75; 72.8%) cases, equivocal in (n = 16; 15.5%), and negative in (n = 10; 10.4%) cases. Sensitivity of ultrasound from this study when compared with ultrasound as the gold standard was 90.2% with a specificity of 85.6%; while Overall accuracy was 72.4%. The calculated kappa scores for inter-observer variability among radiologists were 0.13 to 0.28. Age and gender had no significant relationship with the accuracy of ultrasound in this study ( $p$  value = 0.2 and 0.7 respectively).

**Conclusion:** Ultrasound scan is more useful in detecting than in ruling out appendicitis. The radiological criteria for acute appendicitis, the accuracy of various imaging modalities and the limitations of the available research are described in this series. The interobserver variability in the ultrasonography interpretation of appendicitis is of significant impact in resource- limited surgical emergency settings like ours, which is a rural tropical population in the developing country.

**Keywords:** Appendicitis; Computed tomography; Inter-observer variability; Ultrasonography; Resource- limited settings

## ABBREVIATIONS

AA: Acute Appendicitis; NPV: Negative Predictive Value; PPV: Positive Predictive Value; SPSS: Statistical Package for the Social Sciences; STROBE: The Strengthening The Reporting of Observational Studies in Epidemiology Statement: Guidelines For Reporting Observational Studies; STROCCS: The Strengthening the Reporting of Cohort Studies in Surgery

## BACKGROUND

Appendicitis is a common and important clinical problem that afflicts 8.6% of male and 6.7% of female Americans. There are 250,000 to 300,000 appendectomies, including 60,000 to 80,000 involving children, and more than one million patient-days of hospitalization for appendicitis, each year in the United States [1-3]. There have been reports of increasing incidence of appendicitis in African countries by some authors in the last few decades [4-6]. Changing to a Western lifestyle, including diets have been held responsible for this [7]. It is generally reported to be more common in males [5,8,9] and usually occurs in the age range of 10 to 30 years [5,8,9]; although Mangete from Port-Harcourt in Nigeria found a significantly higher incidence in females [9]. Higher incidences have been reported in the summer months by many authors [4]. Ashley has reported an excess during spring, implicating a high prevalence of viral infections among others during these months [10], but Sanda et al [11], have suggested intense challenge to the mucosa-associated lymphoid tissue from allergens in the dust, during the sandstorms of the spring months, in the Arabian Peninsula. There are problems with the current methods of diagnosis, which are based mainly on the clinical history, physical examination and simple laboratory tests. The classic presentation includes vague mid-abdominal pain, anorexia and nausea, followed by localized Right Lower Quadrant (RLQ) abdominal pain and guarding, and leukocytosis. Up to 45% of cases, however, have atypical symptoms and/or signs [12]. The clinical diagnosis of acute appendicitis is accurate only 70% to 80% of the time [13,14]. Delays in diagnosis often lead to perforation [7], which occurs in 8% to 39% of cases [2,6,8,9]. To prevent perforation, the surgeon may adopt liberal

criteria for surgery, which results in negative appendectomy rates of 15% to 22% [6]. Unnecessary surgery causes pain and inconvenience for patients; wastes precious health care resources and can lead to serious complications [9,14]. Appendicitis is especially difficult to diagnose, and the consequences of error are greater in children, pregnant women and elderly patients [10-14]. These difficulties are due to physiological factors, variations in clinical presentation and, in some cases, problems with communication. Most surveys have found an inverse relationship between rates of perforation and rates of negative appendectomy [15-19]. Therefore, attempts to reduce the rate of unnecessary surgery often lead to unacceptable perforation rates, while a reduction in the latter is generally achieved at the expense of diagnostic accuracy [20-22]. For example, Law et al. [18] reviewed 216 patients with a preoperative diagnosis of appendicitis, and reported a high rate of diagnostic accuracy (89%), together with a high perforation rate (29%).

In contrast, Andersen et al. [19] reviewed 454 patients and reported a much lower perforation rate (8%) at the expense of a lower accuracy rate (67%). This dilemma has been addressed in four ways: This include: (1) Adoption of standardized diagnostic criteria; (2) Observation in hospital of patients with equivocal clinical presentations; (3) Application of diagnostic tests, including radiological imaging; and (4) Use of diagnostic laparoscopy. Several strategies have been employed to improve the accuracy of the diagnosis of appendicitis and to reduce the associated perforation rate [20-22]. Plain abdominal x-rays are nonspecific, barium enema examination has relatively low accuracy, scintigraphy scans require considerable time and are difficult to interpret, and magnetic resonance imaging is relatively unstudied [20-22]. The most promising modalities are graded compression sonography and computed tomography. In expert hands, these techniques can achieve a high degree of accuracy. Nevertheless, most published studies have been marred by methodological difficulties [20-22].

In this study, we reviewed the standardized diagnostic approach in AA and also performed prospective cross observational qualitative testing using Sensitivity, Specificity, Positive Predictive Value (PPV),

Negative Predictive Value (NPV), Accuracy and Kappa score to determine the Interobserver variability in the ultrasonographic interpretation in our resource- limited mission hospital.

## METHODS

### Study design and setting

In this study, we reviewed the standardized diagnostic approach in acute appendicitis and also performed prospective cross observational qualitative testing using sensitivity, specificity, PPV, NPV, accuracy and kappa score to determine the interobserver variability of ultrasonography using the medical database of the two Mission Hospitals, northwestern region of Cameroon from January 2012 to December 2016. Hospital A is a 200-bed Mission Hospital (with 50 surgical beds), while Hospital B is a 250-bed Mission Hospital (with 70 surgical beds). Both Mission Hospitals serve as the main referral centers covering a population in excess of 8 million and a land area with a radius of over 80 km. Also as Medical and Nursing training centers, the hospitals have modeled themselves to attain excellence in standards and its pathology department has no equal in the entire northern half of Cameroon.

### Study population and procedure

A sequential non-randomized convenient sampling was used to prospectively select the study population which consist of operative and laboratory paper-based registers by searching for the keywords appendix and appendectomy. The studied population included patients with age 15 years and above who had appendectomy, with preoperative ultrasound examination and histo-pathological report of the removed appendix. The exclusion criteria were the following:

- i. Patients who did not have pre-operative ultrasound scan
- ii. Patients with any other causes of peritonitis such as ruptured appendix, traumatic perforations, tuberculosis enteric perforations, etc., were excluded from the study.
- iii. All patients with suspected acute appendicitis for whom a laparotomy and histopathological assessment was not performed.

Further information was retrieved from patient records, specifically from the surgeon's operation notes and the histopathology report for all operations undertaken at the Hospitals during this study period covering a period of five years. Information retrieved for each case include the name of the patient, medical record number, age, gender, month of admission, place of domicile, preoperative diagnosis, hospitals where operation was done, the date of the operation, the operative findings including incidental findings and whether or not appendectomy was done as a primary or secondary operation as well as intra-operative diagnosis as recorded in the surgeons operative notes and the histo-pathology report. All the slides of appendectomy cases were retrieved and reviewed. Where slides are missing, fresh sections were taken from tissue cassettes. A positive diagnosis of appendicitis is considered where histologic diagnosis is confirmed whether or not the operative findings concur. A negative histologic diagnosis is taken as normal appendix regardless of the findings in the surgeon's operative notes. The data were compiled in tabular form and remarks were made to explain peculiarities of individual data. Three staff individually took turns to cross check the data for completeness, accuracy and consistency. Pathologically confirmed specimens of appendicitis were analyzed against demographic data of the patients.

### Indications for surgery

According to the general concession by surgeons globally for a liberal attitude to exploration with an accompanying high rate of negative results (up to 50% in women); this has been accepted generally in the hope of preventing perforation of any suspected inflamed appendix [23]. In this respect, perforating and non-perforating appendicitis seemed to be different entities, and spontaneously resolving appendicitis was common [23]. The readiness to explore influences the detection of resolving appendicitis and may explain variations in incidence of appendicitis and perforation rate. Perforation rate is irrelevant as a tool for measuring the quality of management in suspected appendicitis [23].

### Statistical analysis

All data were entered in an excel database (Excel 2007, Microsoft corporation) and analyzed using the Statistical Package for the Social Sciences (SPSS) version 22 where applicable. Calculations include sensitivity, specificity, positive PPV, NPV, Accuracy and Kappa score to determine the interobserver variability of ultrasonography in the study.

### Ethical considerations

Ethical approval was obtained from the Caritas Foundation Healthcare Ethical Review Committee. Approval No: DTAD/10 /482/ 140/ 2019. Confidentiality was ensured by not writing the names of patients on proforma in accordance the Helsinki declaration.

### Reporting

The STROBE/ STROCCS guidelines were used in reporting this study [24,25].

## RESULTS

A total of 103 patients who had pre-operative evaluation with ultrasound scan and subsequently underwent surgery with histo-pathological examination of the removed appendix were analyzed. Their ages ranged from 15 to 65 years with a mean age of  $30.6 \pm 18$ . There were 62 males and 41 females with a ratio of 1.5:1. Of the 103 patients, (n = 90; 87.4%) cases were diagnosed as AA by histopathology while (n = 9; 8.7%) cases were negative. Ultrasound was positive in (n = 75; 72.8%) cases, equivocal in (n = 16; 15.5%), and negative in (n = 10; 10.4%) cases.

Of the 75 with positive ultrasound findings, 68 correlated with histopathology while of the sixteen patients who had equivocal ultrasound findings, 12 had histopathological diagnosis of AA with only four being negative. There were ten patients whose ultrasound was either reported as normal (10 cases), or misdiagnosed as ovarian cyst (2 cases). When compared with the histopathology report, only two of the patients were truly negative while the remaining eight had histo-pathological diagnosis of AA. Sensitivity of ultrasound from this study when compared with ultrasound as the gold standard was 90.2% with a specificity of 85.6%; while Overall accuracy was 72.4%. Age and gender had no significant relationship with the accuracy of ultrasound in this study (p value = 0.2 and 0.7 respectively). The calculated kappa scores for inter-observer variability among radiologists were 0.13 to 0.28.

## DISCUSSION

### Alvarado scoring system

Of the many standardized scoring systems for the diagnosis of acute appendicitis, the Alvarado criteria [26], which generate the

MANTRELS score (Table 1), appear to be the most effective [26]. A score of more than seven points has a relatively high sensitivity (88% to 90%), but the specificity is generally no better than 80%, and is especially low in women [26-28]. Modifications have included removing the leukocyte count criteria or reducing the threshold to five points, but these modifications further impair the specificity of the system, particularly in pediatric patients [27-30]. While these and other criteria may assist junior staff and nonsurgical personnel in identifying patients with appendicitis, they are not likely to be helpful for experienced surgeons who possess astute clinical judgment.

The normal-appearing appendix can be left in situ, thus reducing the rate of negative appendectomy [31-33]. Appendectomy can be carried out safely and quickly with this technique [34-36]. Some authorities recommend that the appendix be removed in all cases, however, because a normal macroscopic appearance does not exclude the presence of histological appendicitis with certainty [37-39]. Moreover, it has been suggested that recurrent pain can arise from appendices that have neurochemical or immunological abnormalities even in the absence of overt inflammation [40,41]. A substantial proportion of patients report a history of recurrent episodes of pain before appendectomy (recurrent appendicitis) or of prolonged pain, which may or may not be accompanied by histological evidence of fibrosis or of chronic inflammation (chronic appendicitis) [42-44].

**Ultrasonography and appendicitis**

Pre-operative evaluation: In a related study by Alegbeleye BJ in 2019 entitled “Ultrasound Scan in the Evaluation of AA in the Tropics” [45]. A retrospective cross-sectional study which assessed the accuracy of preoperative ultrasound scans in the evaluation of patients with suspected AA. One hundred-and-three adult patients with suspected AA who underwent preoperative ultrasound scan of the abdomen and subsequently appendectomy; had the histopathology reports compared with their operative findings [45]. Seventy-five patients of the study population had ultrasound diagnosis of AA, 68 of which correlated well with histopathology. There were 16 patients with equivocal ultrasound findings while ten patients had normal scans and two patients had a misdiagnosis of ovarian cyst. Of the ten, eight had histopathological features of AA [45]. The sensitivity of ultrasound in the study was 90.2% while specificity was 85.6%. The conclusion of the findings from the Alegbeleye B.J study, showed that ultrasound scan in patients with suspected AA provides a high sensitivity and specificity in the diagnosis and therefore a formidable tool for diagnosing AA in low resource center [45].

Diagnostic accuracy of ultrasound scan in appendicitis: The usefulness of ultrasonography in the diagnosis of appendicitis has been known since the early 1980s. It is safe (including during pregnancy) and relatively inexpensive, and can be performed quickly and repeatedly, using portable equipment [46]. The patient can indicate the point of maximal tenderness, to which the transducer can be applied. This can facilitate the diagnosis when the appendix is in an atypical location [46]. Children, because of the relative paucity of intra-abdominal fat and young women, who are susceptible to gynecological disorders, are especially good candidates for sonography. Sonography has, however, several limitations. Some of the limitations are nonspecific: obesity, intestinal gas, patient cooperation, quality of equipment, and the skill and experience of the technician [46]. Other limitations are particularly relevant to AA (Table 2). Some of these limitations have been circumvented by using graded compression, a technique by which the transducer is applied with gradually increasing pressure

to the area of McBurney’s point. Continuous, steadily increasing pressure from the transducer, unlike intermittent application of the device, is tolerated relatively well by patients with AA [46]. Gas artifacts are reduced, because the transducer either compresses or displaces uninflamed loops of bowel. Specifically, compression can expel intraluminal contents from the normal appendix, but not if it is distended and thickened due to inflammation. This technique also brings the transducer closer to the area of the appendix, which allows the use of high-frequency transducers with short focal ranges (such as 5.0 or 7.5 MHz linear-array transducers) [46]. Obesity is still a major problem for sonography. Because it is difficult to approximate the transducer to the appendix, low-frequency transducers (which have long focal ranges but poor resolution) must be used, and it is difficult to apply sufficient pressure to compress the bowel adequately. Furthermore, cases of retrocecal appendicitis can easily be overlooked because of the inability to see through the cecum. Special techniques, such as oblique imaging from a laterally placed transducer [47], may be required in such cases. Pelvic (transvaginal) sonography is also helpful in distinguishing appendicitis from gynecological disorders, especially if transabdominal approaches are inconclusive [48,49]. Disease is confined to the tip of the appendix (distal appendicitis) in 5% to 8% of cases, and can be missed if the entire length of the appendix is not visualized [50-52]. In most normal appendices, ultrasonography can demonstrate an echogenic layer (arising from the submucosa) surrounded by a hypoechoic layer (the muscularis propria) [50]. In some cases, additional luminal, epithelial, subepithelial and serosal structures can be identified and give rise to a ‘target’ appearance. The definition of these layers especially that of the echogenic submucosal layer, is lost with transmural extension of edema, inflammatory infiltrate and necrosis [50-53]. The normal appendix resembles the terminal ileum sonographically, except that the former generally lacks peristalsis, has a blind end, is less than 6 mm in diameter, is round instead of oval in cross-section, and does not change in configuration with time [48]. The key sonographic finding of acute appendicitis is a dilated and non-compressible

**Table 1: Alvarado Scoring System Data [22].**

Clinical or laboratory feature	Points
Migration of pain from the mid-abdomen to right lower quadrant	1
Anorexia or acetonuria (a surrogate marker of food avoidance)	1
Nausea and vomiting	1
Tenderness in the right lower quadrant	2
Rebound tenderness	1
Elevated temperature ( ≥ 38°C)	1
Leukocytosis ( > 10,400 cells/ mm3)	2
Shifted white blood cell count ( > 75% neutrophils)	1
Total possible points 10	10
C° = Degree Celsius; MM³ = Cubic millimeters.	

**Table 2: Limitations of sonography in the diagnosis of acute appendicitis**

1.	Dilation of loops of bowel in the right lower quadrant can obscure the inflamed appendix
2.	The inflamed appendix can be difficult to distinguish from the terminal ileum
3.	The patient may not tolerate application of the transducer to the painful area
4.	The transducer may not have enough spatial resolution to visualize such a small structure as the early inflamed appendix

appendix with a thickened wall. An appendicolith, which can be identified by its acoustic shadow, is found in up to 29% to 36% of cases [50]. The loss of the submucosal echogenic layer, as well as the presence of hyperechoic periappendiceal fat and of a loculated pericecal fluid collection, are said to be indicative of perforation [54-56]. The inflamed appendix is less likely than the normal appendix to contain luminal air [57]. Mesenteric lymphadenopathy is sometimes apparent but can be confused with mesenteric adenitis in children [55, 58-64]. Most authorities have stated that the normal appendix can be visualized by ultrasonography less than 5% of the time [58-60]; therefore, it is easier to establish the diagnosis of appendicitis than to exclude it. There has been considerable discussion about appendiceal diameter, the most widely used diagnostic criterion. Most authorities use a threshold of 6 or 7 mm for appendicitis [46,50,56,58-62], and dilation is often quite obvious [63]. A dilated appendix is not, however, a specific sign of appendicitis [64], because the healthy appendix can dilate in the presence of metabolic disturbances or inflammatory processes elsewhere in the abdomen or pelvis. An appendiceal wall diameter of 3 mm or greater may be more predictive, but effacement of the wall of a much dilated appendix may occur just before rupture [50,51,63]. Moreover, a dilated non-compressible appendix is much less frequently seen after perforation [65,66], probably because of collapse or even disintegration. For this reason, sonography is actually less able to detect perforated than non-perforated AA, although the recent use of more refined techniques has partially overcome this problem [58,66]. Table 2 is a summary of some limitations of ultrasonography use in the diagnosis of acute appendicitis. Many investigators have studied the diagnostic accuracy of ultrasonography for patients suspected of having appendicitis. Some of the largest and best designed of the prospective studies are summarized in table 3. In most cases, graded compression technique was used, but the use of pelvic ultrasonography was usually not discussed specifically. Diagnostic accuracy seems to be similar in women and men [53,67,68], although most investigators have not reported their results separately according to sex. It is also accurate in pregnant

women [62]. Comparable performance characteristics are observed with adult and pediatric patients (Table 3), but it is less sensitive in patients with a body mass index of 25 or greater than in lean patients [62,69]. Some investigators have stated that ultrasonography is more accurate than clinical assessment in diagnosing acute appendicitis [70-71], while others have found that it offers no advantage [65,72]. It has been suggested that the use of ultrasonography would reduce the negative appendectomy rate to 7% or even lower, but the perforation rate is not decreased [65,66,70,73-76]. Many studies may have been biased in favour of sonography. The radiological tests were performed after the initial clinical assessment with which they were compared, and thus after the illness had progressed. Not all patients underwent surgery, and it was not always clear that the ultrasound results did not influence the decision to operate. These factors introduce possible verification bias. The interactive nature of sonography could also have introduced additional biases, in that patients with localized pain and tenderness (i.e., those with a high pretest probability of a surgical condition) would be more likely to have a definitive ultrasonography result than those without localizing symptoms or signs [77,78]. Ultrasonography was generally performed and interpreted by experts in the field, whereas clinical assessments were often performed by junior surgeons, surgical residents or others using clinical scoring systems [70,72,76,79].

**Interobserver variability**

In this series, the calculated kappa scores for inter-observer variability among radiologists were 0.13 to 0.28 which was comparable to other study where the kappa scores for intra and inter observer variability among radiologists were only 0.39 to 0.42 and 0.15 to 0.20, respectively [80]. This reinforces the common assertions that sonography is highly dependent on technical expertise and the nature of the equipment, however, and it is unlikely to perform as well in non-specialized centers as in research centers [47,81-84]. A shortcoming that is common to all of these investigations is the failure either to apply strict histological criteria for the diagnosis of appendicitis or

**Table 3:** Prospective studies of sonography in the diagnosis of acute appendicitis.

Author, year (reference)	n	Acute Appendicitis (%)	Sensitivity (%)	Specificity (%)	PPV (%)	NPV (%)	Accuracy (%)
Puylaert et al, 1987 (58)	60	47	89	100	89	91	95
Abu-Yousef et al, 1987 (54)	68	37	80	95	91	89	90
Jeffrey et al, 1988 (53)	250	36	90	96	93	94	94
Schwerk et al, 1990 (105)	857	23	90	98	94	97	96
Davies et al, 1991 (86)	152	27	96	94	96	94	95
Rioux, 1992 (102)	170	26	93	94	86	98	94
Sivit et al, 1992 (106)*	180	29	88	82	90	79	86
Chen et al, 1998 (103)	191	75	99	68	90	97	92
Schulte et al, 1998 (104)*	1285	9	92	98	90	98	98
Sivit et al, 2000 (100)*	315	26	78	93	79	92	89
Douglas et al, 2000 (73)	129	46	95	89	88	95	91
Poortman et al, 2003 (5)	199	70	76	79	90	64	78
Peixoto et al, 2011 (99)	156	55	65	72	92	28	70
Subash et al, (98)	125	70	95	89	98	80	82
Alegbeleye, 2018 **	103	75	90	86	76	73	72

\*Studies comprised exclusively pediatric patients (other studies comprised mainly adults).

NPV- Negative predictive value; PPV- Positive predictive value

\*\* (Study comprised exclusively of adult patients in this PhD Thesis)

to estimate the interobserver variability for pathologists or for the radiologists. Variability in the histological criteria can affect the sensitivity and specificity of the tests [85]. Moreover, entry criteria are often vague, and patients with a wide range of pretest likelihood of having acute appendicitis may be included. Most surgeons urgently operate on patients with typical clinical findings of appendicitis, and do not appreciate the delay caused by obtaining a sonogram [48,49]. It appears that a substantial minority (8% to 26%) of patients with clinically typical appendicitis have false-negative ultrasonography scans [75,86-89]. Sonography may be more useful in equivocal cases. Orr et al. [90] undertook a meta-analysis of 17 studies (including 3358 patients) published between 1986 and 1995, and categorized patients according to their likelihood of appendicitis-high, intermediate and low (with disease prevalence of 80%, 40% and 2%, respectively). They found that, in the high-risk group, the positive predictive value of ultrasonography was 97.6% but the negative predictive value was only 59.5%; in the low risk group, on the other hand, the negative predictive value was 99.7% but the positive predictive value was only 19.5%. They concluded that sonography was most useful for patients with intermediate clinical risk of appendicitis. Other investigators have found that ultrasonography is cost effective only for patients with equivocal clinical findings [91-93]. Another fundamental weakness of most ultrasonography studies is the failure to address inconclusive test results adequately. Sometimes, the failure to visualize the appendix is regarded as evidence against the diagnosis of appendicitis [65]; however, this assumption may not be valid. In other studies, inconclusive results (such as an appendix of 5 to 7 cm in diameter) lead to further radiological investigation (e.g., CT scanning or Doppler ultrasonography). It would be preferable if investigators acknowledged the proportion of indeterminate tests.

Another problem occurs when the sonogram suggests the presence of appendicitis (i.e., a dilated, non-compressible appendix), but the patient's illness resolves spontaneously [52,66,94,95]. Are these cases of self-limited AA, or do they represent false-positive ultrasonography results? Such patients generally are not subjected to immediate surgery, although some have further episodes of pain and ultimately undergo appendectomy. It has been suggested that the risk of eventual recurrence is higher in patients with previous episodes of typical pain and in those with appendicolithiasis [94-97]. When surgery is not performed in patients who have undergone radiological investigation, it is crucial for the investigator to ensure sufficient follow-up to detect cases of recurrent or chronic appendicitis. Studies vary in the extent to which this has been done; and Table 3 is a classical illustration of the various prospective studies of sonography in the diagnosis of acute appendicitis and their outcomes in terms of sensitivity, specificity, PPV, NPV, and accuracy as a determinant of the interobserver variability in the interpretation and reporting of ultrasonographic findings in patients with suspected AA (5,58,59,73,86,97-106). The kappa score further reinforced our findings that two sonologists produce a statistically significant variability in the interpreted reports. Even if symptoms do not recur, the failure to operate on all patients with positive (or negative) scans interferes with the ability to determine the true sensitivity and specificity of the imaging modality. This radiological picture above is often not the case in reality (in most clinical settings) with management of AA. A few of the patients were managed basically non-operatively with antibiotics. Others eventually had different diagnoses for which they were invariably managed; for instance, torsion of the right ovarian cyst, right tubal ectopic gestation either ruptured or concealed.

## CONCLUSION

Ultrasound scan is more useful in detecting than in ruling out appendicitis. The radiological criteria for acute appendicitis, the accuracy of various imaging modalities and the limitations of the available research are described in this series. Even in well established centers worldwide, there are obviously differences in interpretation of ultrasonographic findings amongst radiologists or sonologists also termed interobserver variability. However, this interobserver variability in the ultrasonography interpretation of appendicitis is of significant impact in resource-limited surgical emergency settings like ours, which is a rural tropical population in the developing country.

## DECLARATIONS

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**Authors' Contributions:** The author conceived of the study and participated in its design and coordination as well as helped to draft the manuscript; the author also read and approved the final manuscript.

**Ethics Approval and Consent to Participate:** Ethical approval was obtained from the Caritas Foundation Healthcare Ethical Review Committee. Approval No: DTAD/10/482/140/2019. Confidentiality was ensured by not writing the names of patients on proforma in accordance with the Helsinki declaration. A copy of the written Approval is available for review by the Editor-in-Chief of this journal.

**Consent for Publication:** Written informed consent was obtained from the patient for publication of this clinical research study and any accompanying images. A copy of the written consent is available for review by the Editor-in-Chief of this journal. Trial Registration also with Pan African Clinical Trial Registry unique identification number for the registry is PACTR201903475913135.

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