

Original Article

Comparative Study of Alvarado Score and its Modifications in the Preoperative Diagnosis of Acute Appendicitis at a Tertiary Center in Sokoto, Nigeria

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ABSTRACT

Background: Decision-making in patients suspected of having acute appendicitis has remained a diagnostic challenge worldwide despite the advances in imaging and appendiceal surgery. There have been efforts to improve the diagnosis of appendicitis using clinical scoring systems. **Aim:** We evaluated and compared the diagnostic accuracy and role of Alvarado score (AS) and two of its modification (Kalan and Al-Fallouji) in the preoperative diagnosis of acute appendicitis. **Materials and Methods:** This was a prospective study conducted at the Usmanu Danfodiyo University Teaching Hospital, Sokoto, of all adult patients operated for acute appendicitis from July 2014 to June 2017. The results were analyzed on computer using Statistical Package for the Social Science version 15. **Results:** One hundred and eleven patients were studied. Sixty-six (59.5%) patients were males and 45 (40.5%) were females. The male-to-female ratio was 1.5:1. The mean age was 23.89 ± 4.93 years. The AS sensitivity, specificity, positive predictive value, negative predictive value, and diagnostic accuracy of 90.3%, 83.3%, 96.6%, 62.2%, and 89.2%, respectively, were similar to the findings of Kalan score (90.3%, 83.3%, 96.6%, 62.5%, and 89.2%, respectively) and Al-Fallouji score (96.8%, 66.7%, 93.8%, 80%, and 91.9%, respectively). The receiver operating curve and area under the curve show that Alvarado, Kalan, and Al-Fallouji are accurate scores in the preoperative diagnosis of acute appendicitis with an area under the curve of 0.88, 0.86, and 0.85, respectively. **Conclusion:** Kalan and Al-Fallouji scores have comparably good diagnostic accuracy as the AS among our patients. Any of these scores can be used as an adjunct in the preoperative diagnosis of acute appendicitis.

KEYWORDS: *Acute appendicitis, Al-Fallouji score, Alvarado score, appendicectomy, diagnostic accuracy, Kalan score, modified Alvarado score, Nigeria, sensitivity, specificity*

Received : 26-09-2019
Revision : 15-11-2019
Accepted : 16-12-2019
Published : 10-02-2020

INTRODUCTION

Appendicitis continues to remain a diagnostic challenge after over a 120 years since its first description.^[1] This common surgical disease can surprise the best of clinicians, especially in the extremes of age and among females.^[2] Delay in diagnosis definitely increases the morbidity, mortality, and cost of treatment.^[2] Surgeons may be inclined to operate when the diagnosis is probable rather than certain. This clinical decision may lead to removal of a normal appendix in 20%–40%

of cases.^[3] Removing normal appendix is an economic burden both on patients and health resources.^[4]

The diagnostic accuracy varies from 25% to 90%, optimal accuracy rate is 80%, and diagnostic error rate

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How to cite this article: Umar MM, Abubakar IU, Agbo SP. Comparative study of alvarado score and its modifications in the preoperative diagnosis of acute appendicitis at a tertiary center in Sokoto, Nigeria. *Niger J Surg* 2020;26:16-21.

Access this article online	
Quick Response Code: 	Website: www.nigerianjsurg.com
	DOI: 10.4103/njs.NJS_46_19

is 25% and twice as common in female as in males.^[5] Difficulty in diagnosis arises more in very young patients, elderly patients, and females of reproductive age because they usually have atypical presentation in the first two, while many other conditions also mimic appendicitis in females of reproductive age group. Literature shows that 3%–7% of all adults on exploration for acute appendicitis have diseases other than appendicitis.^[6]

A drive, therefore, has been to improve the diagnosis of appendicitis using clinical scoring systems. These systems have been based on symptoms, signs, and laboratory findings. In some instances, they have been part of a computer-aided diagnostic algorithm.^[7] The most widely cited score in the diagnosis of adults with acute appendicitis is the Alvarado score (AS).^[7]

The AS was developed by Alfredo Alvarado in 1986 as an aid to the diagnosis of appendicitis. The score was based on a retrospective study conducted on 305 patients hospitalized at the Nazareth Hospital in Philadelphia, Pennsylvania, USA, with abdominal pain suggestive of acute appendicitis.^[8] Signs, symptoms, and laboratory findings were analyzed for specificity, sensitivity, predictive value, and joint probability.^[9] The total joint probability, the sum of a true positive and a true negative result, was chosen as diagnostic weight indicative of the accuracy of the test.^[8] Eight predictive factors were found to be useful in making the diagnosis of acute appendicitis.^[8] AS has shown encouraging results among African patients.^[10] Kanumba *et al.*^[10] in their study among Tanzanian patients showed that the use of modified AS (MAS) in patients suspected to have acute appendicitis provided a high degree of diagnostic accuracy and can reduce negative appendectomy and complication rates.

There has been modification of the original AS mainly due to unavailability of routine reporting of shift to the left of neutrophils maturation by laboratories in some medical facilities where the AS has been evaluated.^[11,12]

The unavailability of routine reporting of shift to the left of neutrophils outside normal working hours made these modifications of Alvarado relevant in our setting. Despite this, there is a dearth of studies comparing Alvarado and its modifications among African patients. We, therefore, compared the diagnostic accuracy of AS and two of its modification, Kalan and Al-Fallouji.

MATERIALS AND METHODS

Design

This was a prospective study conducted at the Usmanu Danfodiyo University Teaching Hospital (UDUTH), Sokoto, over a 3-year period (July 2014 to June 2017).

UDUTH is a 572-bed tertiary referral hospital in Northwestern Nigeria with a predominant Hausa-Fulani population.

Inclusion criteria

- All consenting consecutive patients during the study period operated with an initial clinical diagnosis of acute appendicitis
- Patients who are 16 years or older.

Exclusion criteria

- Patients who withhold or are unable to give consent
- Patients <16 years
- Patients not operated
- Patients with demonstrable extra appendicular cause (radiologic or intraoperative) of pain in the right iliac fossa.

Method

The demographic characteristics of the patients; history; physical examination findings including cough, psoas, and obturator signs; concomitant diseases; blood parameters; abdominal ultrasound findings; surgical findings; and histopathological findings were recorded on a pro forma.

All the individual parameters required to score both the Alvarado and MASs – the Kalan and Al-Fallouji were recorded individually and scattered in different areas of the pro forma to make spot calculation difficult. The total score was not calculated until after the appendectomy.

The decision to perform appendectomy was made solely on the clinical features of the patient and not influenced by the score. To guarantee this, the actual summation of the scores from the various parameters of the AS and MAS (Kalan and Al-Fallouji) was not done until after the surgery.

After the appendectomy, the AS was calculated. The patients were assigned to the following four groups based on the score.

Unlikely	-	AS 1–4
Compatible	-	AS 5–6
Probable	-	AS 7–8
Definite	-	AS 9–10.

The MAS was calculated as described by Kalan *et al.*^[11] Bengezi (Al-Fallouji)^[12] was also calculated postoperatively. Classification of patients is similar to the AS.

Data analysis

The results were analyzed on a computer using the Statistical Package for the Social Sciences (SPSS) version 15 (SPSS) Inc. Chicago, IL, USA.

ASs and MASs were correlated with histopathological findings. Negative appendectomy rate (NAR), positive and negative predictive value (NPV), sensitivity, specificity, and accuracy were calculated.

Multivariate analysis was done to determine the effect of age, sex, and duration of symptoms on the accuracy of Alvarado.

The level of statistical significance was set at $P \geq 0.05$.

Ethical clearance

Ethical clearance was obtained from the Ethics Committee of the UDUTH, Sokoto. The ethical clearance approval number is UDUTH/HREC/2014/No. 278.

RESULTS

A total of 111 patients who met the inclusion criteria were studied among which 66 (59.5%) were males and 45 (40.5%) were females, giving a male: female ratio of 1.5:1. The age range was between 16 and 38 years. The mean age was 23.89 ± 4.93 years [Figure 1].

Majority (72 [64.9%]) of the patients were students among which 69 (62.4%) patients had a tertiary education. They were predominantly of the Hausa/Fulani tribe (78.4%).

All the patients presented with an abdominal pain and abdominal tenderness in the right iliac fossa. Other common presentation included anorexia and nausea/vomiting which constituted 87 (78.4%) patients and 99 patients (89.2%), respectively. Rebound tenderness was present in 108 (97.3%), cough sign in 96 (86.5%) patients, psoas sign in 66 (59.5%) patients, obturator sign in 30 (27%) patients, and Rovsing's sign in 51 (45.9%) patients. Table 1 shows the clinical findings among the patients.

Majority of the patients (24 [72.7%]) of the 33 patients) who had perforation presented after 24 h ($P = 0.02$). All the patients who had a perforated appendicitis had an Alvarado, Kalan, or Al-Fallouji score of >6 .

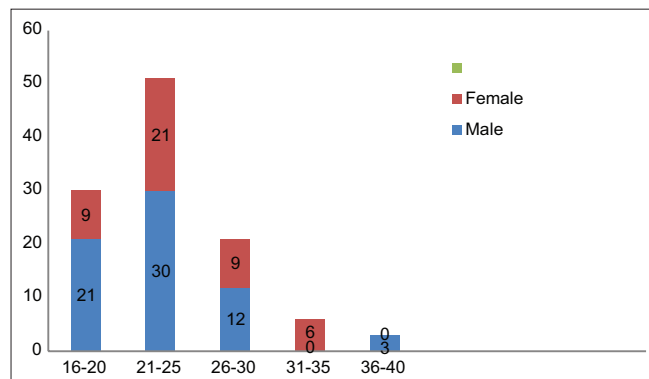


Figure 1: Age/sex distribution of patients with appendicitis

Majority of the patients (105 [94.6%]) patients had a leukocyte count of 4000–11,000 cells/ml and only 42 (37.8%) patients had a shift to the left.

The mean scores of Alvarado, Kalan, and Al-Fallouji modification of Alvarado were 8.05 ± 1.68 , 7.7 ± 1.49 , and 8.6 ± 1.54 , respectively. The sensitivities, specificities, positive and NPVs, and diagnostic accuracies of the various scores are shown in Table 2.

NAR was 16.2%. A cutoff of 7 was used as a criterion for surgery, using derivative statistical calculations; the NAR so calculated was 3.45% ($P < 0.001$) on the Alvarado or Kalan scoring systems. However, the calculated NAR was 6.25% if in a similar vein a presumptive cutoff of 7 was used on the Al-Fallouji scoring system.

Receiver operating characteristic curve (ROC) is a plot of the true-positive rate against the false-positive rate for the different possible cutoff points of a diagnostic test. The closer the curve follows the left hand border and then the top border of the ROC space, the more accurate the test. The area under the curve (AUC) is a measure of test accuracy whose score of 0.8 and above depicts an accurate test, whereas 0.5 a worthless test.

Table 1: Clinical Findings among the patients

Symptoms/sign	Frequency (n=111), n (%)
Abdominal pain	111 (100)
Lower abdominal pain	108 (97.3)
Migratory RIF pain	87 (78.4)
Anorexia	87 (78.4)
Nausea/vomiting	99 (89.2)
Fever	57 (51.4)
History of similar symptoms	36 (32.4)
Urinary symptoms	18 (16.2)
Abdominal tenderness	111 (100)
Rebound tenderness	108 (97.3)
Pyrexia	54 (48.6)
Psoas sign	66 (59.5)
Obturator sign	30 (27)
Rovsing's sign	51 (45.9)
Cough sign	96 (86.5)
Rectal tenderness	6 (5.4)

RIF: Right iliac fossa

Table 2: Accuracy of Alvarado and modified Alvarado scores (Kalan and Al-Fallouji)

Score	Sensitivity	Specificity	PPV	NPV	Accuracy	P
Alvarado	90.3	83.3	96.6	62.5	89.2	0.001
Kelan	90.3	83.3	96.6	62.5	89.2	0.001
Al-Fallouji	96.8	66.7	93.8	80	91.9	0.001

Histological analysis was used as gold standard for diagnosis, Accuracy: True positive + true negative/total number of patients. PPV: Positive predictive value, NPV: Negative Predictive value

Table 3: Association between some patient variables and Alvarado score

	Alvarado score				P
	<4	5-6	7-8	9-10	
Age (years)					
16-20	3	9	9	9	0.140
21-30	3	9	21	39	
30-40	0	0	3	6	
Sex					
Male	3	12	21	30	0.941
Female	3	6	12	24	
Duration of symptoms in days					
<1	3	15	15	27	0.638
1-2	3	0	12	18	
3-7	0	3	6	3	
>7	0	0	0	6	

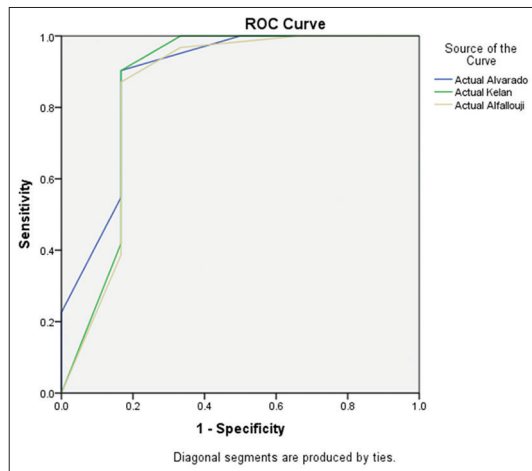


Figure 2: Receiver operating characteristic curve for Alvarado, Kalan, and Al-Fallouji scores

The ROC and AUC show that Alvarado, Kelan, and Al-Fallouji are accurate scores in the preoperative diagnosis of acute appendicitis with an AUC of 0.88, 0.86, and 0.85, respectively [Figure 2].

A multivariate analysis of the patients’ age, sex, and duration of symptoms before presentation showed no significant association between these variables and AS [Table 3].

DISCUSSION

Vermiform appendix, though described anatomically to be vestigial, is one of the most important surgical organs in the human body. There are many disease conditions involving this organ among which acute appendicitis is the most common. Appendicitis is an inflammatory condition of the vermiform appendix affecting mainly adolescents and young adults.^[13]

The incidence among Africans and Asians has consistently been reported to be low. Reports from

Africa put the prevalence around 1%.^[14] The finding of this study of yearly hospital-based presentation of 37 patients with a male-to-female ratio of 1.5:1 and a peak age incidence of 20–24 years mirrors what has been reported in a previous hospital-based study from Nigeria.^[15-17] The age and sex distribution is in agreement with the reported epidemiology of the disease in the United states where the highest incidence of positive appendectomy (appendicitis) is found in persons aged 10–29 years. Males had higher rates of appendicitis than females for all age groups, with an overall rate ratio of 1.4:1.^[18]

AS is reported by some workers as the best performing of the clinical scoring systems for acute appendicitis in use and is therefore the most widely used.^[4] Kalan *et al.* modified the original AS by excluding shift to the left of neutrophil maturation.^[11] They found that a high MAS was an easy and a satisfactory aid to early diagnosis.^[11] Several studies have evaluated and validated the Kalan modification of AS in adult surgical practice.^[10,19] Bengezi and Al-Fallouji in their prospective study of 345 consecutive patients admitted with a diagnosis of acute appendicitis introduced another modification of AS; they also omitted the shift to the left of neutrophil maturation but introduced an extra sign (cough test, Rovsing’s sign, and rectal tenderness).^[12] They concluded that their MAS was simpler, was easier to read and interpret, and was more practical and reliable than the original AS.^[12] This modification has been validated in surgical practice.^[20-22]

In this study using a cutoff of 7 for the AS s, sensitivity, specificity, positive predictive value, NPV, and diagnostic accuracy of 90.3%, 83.3%, 96.6%, 62.2%, and 89.2%, respectively, were similar to the findings for Kalan scores (90.3%, 83.3%, 96.6%, 62.5%, and 89.2%, respectively) and Al-Fallouji scores (96.8%, 66.7%, 93.8%, 80%, and 91.9%, respectively). However, Al-Fallouji showed a slightly higher sensitivity and diagnostic accuracy than the other two scores.

Similar finding was also demonstrated in a Thai study by Phrophrom and Trivej^[23] in their comparative study using Bengezi’s MAS and the original AS, which showed that the accuracy of the Bengezi MAS was slightly greater than the original Alvarado in the diagnosis of acute appendicitis. Fente and Echem^[22] in a similar prospective study evaluated the Bengezi and Al-Fallouji modification of the AS among acute appendicitis patients presenting to a tertiary hospital in South-South Nigeria and also found a high sensitivity of 92.93% and a specificity of 92.93%. Similar findings were reported by studies from other parts of the world.^[24]

Kalan *et al.* in a similar prospective study of 49 patients who were sick enough to warrant surgery for suspected appendicitis found that a high MAS was an easy and a satisfactory aid to the early diagnosis of appendicitis in children and men with sensitivity of 93% and 100%, respectively, but the results were disappointing in women where sensitivity was only 67%.^[11] Unlike what was reported by Kalan *et al.*, there was no statistically significant difference in accuracy of this score between female and male patients ($P < 0.941$) in our study. This could be explained by the fact that we excluded any demonstrable extra appendicular cause of right iliac fossa pain in our study population. It could therefore be postulated that these extra appendicular causes of right iliac fossa pain (demonstrated in this study mainly by abdominal ultrasound) are responsible for poor diagnostic accuracy of AS among females. A well-designed randomized study is needed to confirm this. Kanumba *et al.*^[10] in their study among Tanzanian patients showed that the use of MAS (Kalan) in patients suspected to have acute appendicitis provided a high degree of diagnostic accuracy and can reduce negative appendectomy rate and complication rates, however they concluded that additional investigations may be required to confirm the diagnosis in the case of atypical diagnosis.

A slightly higher diagnostic accuracy of Al-Fallouji MAS than the AS (91.9% for Al-Fallouji as against 89.2% Alvarado) may be partly explained by the relatively low white blood cell (WBC) count among Africans as compared to Caucasians, which was also demonstrated in this study and therefore the low diagnostic weight of leukocytosis and shift to the left as compared to the high diagnostic weight demonstrated by Alvarado.^[8] The lower WBC and neutrophil among African descents has been referred to as ethnic neutropenia.^[25] The reason for the difference between Africans and White patients is largely unclear, with many researchers accepting the genetic hypothesis.^[25] Mechanisms postulated for the low counts include low release of mature granulocytes, altered bone marrow reserve, and Duffy null polymorphism.^[25,26]

The ROC curve for the three scores showed an AUC of 0.88, 0.086, and 0.85 for Alvarado, Kalan, and Al-Fallouji, respectively. This further confirms the diagnostic accuracy of all these scores. This is similar to what was reported by previous workers.^[27,28] This is similar to the findings of an Iranian study by Nasiri *et al.* who studied 75 patients who had appendectomy over a 9-month period and also found an AUC of 0.837.^[27]

Histological analysis showed a NAR of 16.2%, which is similar to a previous report from our hospital

by Mungadi *et al.*^[16] Using an AS cutoff of 7 as a criterion for appendectomy, the NAR will reduce to 3.45% ($P < 0.001$). The reduction in NAR is same if the same cutoff is applied to Kelan and 6.25% for Al-Fallouji. This is desirable to prevent unnecessary surgeries and sequel of morbidities and economic burden on our patients. This will also help reduce the burden on the already-weak health-care delivery system. Similar reduction in NAR was also demonstrated by Fente and Echem in their study among patients presenting to a tertiary hospital in South-South Nigeria.^[22]

The rate of perforation in our study was 29.7%, which is comparable to previous studies carried out in Northern Nigeria.^[17,29] A finding in this study of a significant statistical relationship between perforated appendix and all the three scores ($P = 0.0001$, $P = 0.002$, and $P = 0.0001$) for Alvarado, Kalan, and Al-Fallouji, respectively (with no patient with perforated appendix having a score of <7 regardless of the scoring system), further confirms the usefulness of all the three scores in the preoperative diagnosis in our setting.

CONCLUSION

MASs (Kalan and Al-Fallouji) have comparably high sensitivity, specificity, and good diagnostic accuracy as the AS among our patients. These modifications can, therefore, be used to circumvent the difficulty of obtaining the result of shift to the left in neutrophils. Any of the three scores is useful as an adjunct in the preoperative diagnosis of acute appendicitis.

Financial support and sponsorship

Nil.

Conflicts of interest

There are no conflicts of interest.

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