



ORIGINAL ARTICLE

COMPARATIVE STUDY OF DIAGNOSTIC ACCURACY OF MODIFIED ALVARADO SCORE,
ULTRASONOGRAPHY AND OPERATIVE FINDINGS IN RELATION TO HISTOPATHOLOGICAL
REPORTS IN ACUTE APPENDICITIS

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ABSTRACT

Objective: To assess the diagnostic accuracy of modified Alvarado scoring system, abdominal ultrasonography and operative findings in comparative to histopathological study in patients suffering from acute appendicitis.

Methods and Patients: This was a prospective study of 100 patients who underwent appendectomy for suspected acute appendicitis. The patients were of both males and females their age ranged from 12- 47 years. The data were collected within one year including sociodemographic data, Modified Alvarado Scoring System (MASS), abdominal ultrasonography, operative findings which were correlated with histopathological reports. Also operative procedure done, postoperative complications, hospital stay and outcome.

Results: Out of 100 patients, the maximum percentage of patients were in age group 21-40 years (56%), males more than females (68% vs 32%, ratio 2.13:1). 76% had MASS ≥ 7 , 68% had +ve ultrasonography findings for acute appendicitis. Histopathological positive reports were 80%. Ultrasonography compared to histopathology reports shows, sensitivity = 60%, specificity = 0%, PPV = 70.59%, NPV = 0% and accuracy = 30%. MASS compared to histopathology reports at cutoff point = 6 shows, sensitivity = 90%, specificity = 40%, PPV = 85.71%, NPV = 50% and accuracy = 65%. Also, MASS compared to histopathology reports at cutoff point = 7 shows, sensitivity = 85%, specificity = 60%, PPV = 89.47%, NPV = 50% and accuracy = 72.50%. ROC curve for diagnosis of acute appendicitis according to MASS:- AUC = 0.87, standard error = 0.034 and CI = 0.80-0.93. Both MASS and histopathological positive reports were more prevalent among all age groups at cutoff point ≥ 7 than at cutoff point < 7 . MASS at cutoff point = 7 shows more Sensitivity, specificity, positive predictive value, negative predictive value and accuracy in males (86.67, 100, 100, 50, 93.33 respectively) than females (80.00, 33.33, 66.67, 50, 56.67 respectively).

Conclusion: From present study, it is concluded that modified Alvarado scoring system is better diagnostic tool than ultrasonography alone in diagnosis of acute appendicitis because of the MASS provides high degree of sensitivity, specificity, PPV, NPV and accuracy in diagnosis of acute appendicitis in relation to histopathological study. MASS has to be more helpful in male patients by showing lower negative appendectomy rate and high sensitivity, specificity, PPV and accuracy for male patients as compared to females. But still neither MASS nor ultrasonography is absolute tool in reducing negative appendectomy in patients of suspected appendicitis.

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INTRODUCTION

Acute appendicitis is one of the most common surgical emergencies. Simple appendicitis can progress to perforation which is associated with much higher morbidity and mortality, and surgeons have therefore been inclined to operate when the diagnosis is probable rather than wait until it is confirmed (Hoffmann *et al.*, 1989).

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This making the decision for surgical operation based only on the patient's symptoms and signs results in removing normal appendices (negative appendectomy) in 15% to 30% of cases (Gokce *et al.*, 2011). The rational approach is to decrease the negative appendectomy as well as rupture appendix rates, decrease in unnecessary appendectomies should not cause an increase in rate of perforated appendix (Velanovich *et al.*, 1992). Various radiological imagings like plain X-ray, graded compression ultrasonography, color Doppler ultrasonography, abdominal C T scan and MRI has been developed for more accurate diagnosis of acute appendicitis, but no one is

confirmatory (Moberg *et al.*, 1998). Graded compression ultrasonography is a fast, inexpensive and noninvasive method with an accuracy rate of 71% - 90% for the diagnosis of acute appendicitis (Horzic *et al.*, 2005). But ultrasonography is an operator- dependent modality, and the diagnostic values are different in various studies (Stoker *et al.*, 2009). Also there is no certainty about the effect of ultrasonography on the clinical outcome of patients (Kanumba *et al.*, 2011). Therefore, clinical judgment should not be abandoned because of the lack of ultrasound findings in patients with a high probability of acute appendicitis (Lee *et al.*, 2001). Scoring system for early diagnosis of acute appendicitis was developed by Alvarado in 1986, based on clinical signs, symptoms and differential leucocyte count, with a left shift of neutrophil maturation yielding a total score of 10, known as Alvarado score (Alvarado *et al.*, 1986). Kalan *et al* omitted the left of shift to neutrophil maturation parameter and produced a Modified Alvarado Score, it is 9 point scoring system that helps in increasing the accuracy of preoperative diagnosis and thus reducing negative appendectomy rate. Score of 7 or more were recommended for surgery (Kalan *et al.*, 1994). The aim of this study was To assess the diagnostic accuracy of modified Alvarado scoring system, abdominal ultrasonography, operative findings in comparative to histopathological study in patients suffering from acute appendicitis.

PATIENTS AND METHODS

This was a prospective study of acute appendicitis victims (with exclusion of patients with generalized peritonitis due to appendicular perforation and also those suffering from appendicular mass) submitted to urgent appendectomy from any age and sex, admitted to the emergency department of Aswan University Hospital-Egypt. In a period from 1st September 2016 to 30th August 2017. The number of cases were one hundred (100) patients underwent urgent appendectomy and analysis of their records. Data were collected by us and our residents in emergency department of Aswan University Hospital. The consent was taken from patients or their guardians and relatives. Diagnosis of acute appendicitis was made based on clinical and radiological criteria. The collected data include :- **a)** Socio-demographic data for each patient in the form of (age, sex, social status, special habits, residence, job and country). **b)** Clinical data :- Vital signs (pulse rate, blood pressure, temperature and respiratory rate). Modified Alvarado Scoring System (MASS) in acute appendicitis including :-

Modified Alvarado Scoring system

Symptoms

-Migrating Rt. Iliac Fossa Pain-----1
 -Anorexia-----1
 -Nausea/ Vomiting-----1

Signs

-Tenderness Rt. Lower Quadrant-----2
 -Rebound tenderness Rt. Iliac Fossa-----1
 -Pyrexia > 37.3 °C-----1

Investigations

-Leucocytosis > 10 X 10⁹ L-----2
Total-----9

Modified Alvarado scoring system more than or equal to 7 are considered positive (+ ve) and scores less than or equal to 6 are considered negative (- ve). **c)** Investigations:- 1- Laboratory investigations:-a- white blood cells (leucocytosis > 10X10⁹/L or > 10000/ul). b-Histopathological study after removal of the appendix (Histopathological report (HPR) considered +ve when the appendix was inflamed and -ve when the appendix was not inflamed). 2- Radiological investigations, in the form of Graded compression abdominal ultrasonography, the ultrasonography findings were divided into two groups according to the findings i.e. ultrasonography positive (+ve) means non compressible blind loop equal to or greater than 6 mm in anteroposterior diameter indicate appendicitis, and ultrasonography negative (-ve) appears as compressible with wall thickness of less than or equal to 3 mm indicate normal appendix. The size of an appendix can differentiate normal from an acutely inflamed appendix. **d)** Intraoperative findings (Acute catarrhal appendicitis, a cute suppurative appendicitis, gangrenous appendix, Perforated appendix, appendicular abscess and normal appendix). **e)** The operative procedures done during the operation (Appendectomy without drain, appendectomy with drain, Drainage of pus without removal of the appendix, Right hemi colectomy). **f)** Length of hospital stay. **g)** Post-operative complications (wound hematoma, wound infection, wound dehiscence, abdominal distension, fecal fistula, chest infection, vomiting and re-exploration). **h)** Outcome of patients.

STATISTICAL ANALYSIS

Data was analyzed using STATA intercooled version 12.1. Quantitative data was represented as mean, standard deviation, median and range. Qualitative data was presented as number and percentage. Data were analyzed by sensitivity, specificity, positive, and negative predictive value derived from the receiver operating characteristic (ROC) curve. Graphs were produced by using Excel or STATA program. P value was considered significant if it was less than 0.05.

RESULTS

Out of 100 patients studied in this research, the age incidence varies between 12 to 47 years, the maximum incidence of acute appendicitis was found in age group of 21- 40 years (56 patients (56%)), followed by age group of ≤20 years (28 patients (28%)) and lastly the age group of 41-60 years (16 patients (16%)). Regarding to sex, males were more than females (68 males (68%) vs 32 females (32%) with a ratio of 2.13:1 respectively). Married patients were suffering from acute appendicitis more than single patients (52% vs 48% respectively). Regarding to job, students were the maximum job suffering from acute appendicitis (32%) followed by workers (28) then house wife (20%).

Acute appendicitis were more prevalent among urban country than rural (60% vs 40%). Also Cigarette smokers were more prevalent among patients suffering from acute appendicitis than Goza smokers (36% vs 8%), as shown in Table (1). Regarding to the modified Alvarado scoring system (MASS) components among 100 patients, 96 (96%) had tender Rt. lower quadrant and anorexia, 88 (88%) had rebound tenderness Rt. iliac fossa, 84 (84%) had nausea/ vomiting, 80 (80%) had leucocytosis and 68 (68%) had migrating Rt. iliac fossa pain and pyrexia. 84 patients (84%) had MASS ≥ 6 and 16 patients (16%) had MASS < 6.

Table 1. Sociodemographic characteristics of studied populations

Variable	Summary statistics
Age/years	
Mean ± SD	26.52±10.06
Median (min-max)	26 (12-47)
Age groups	
≤20	28 (28.00%)
21-40	56 (56.00%)
41-60	16 (16.00%)
Sex	
Females	32 (32.00%)
Males	68 (68.00%)
Male: Female ratio	2.13: 1
Marital status	
Married	52 (52.00%)
Single	48 (48.00%)
Job	
No work	4 (4.00%)
House wife	20 (20.00%)
Student	32 (32.00%)
Engineer	12 (12.00%)
Teacher	4 (4.00%)
Worker	28 (28.00%)
County	
Rural	40 (40.00%)
Urban	60 (60.00%)
Special habits	
Cigarette	36 (36.00%)
Goza	8 (8.00%)
Others	4 (4.00%)

Also 76 patients (76%) had MASS ≥ 7 considered as MASS positive (+ve) and 24 patients (24%) had MASS < 7 considered as MASS negative (-ve), as shown in Table (2) and fig. (1).

Table 2. Distribution of Modified Alvarado scoring system components among studied populations

Variable	Summary statistics
Symptoms	
Migrating. Rt. iliac fossa pain	68 (68.00%)
Anorexia	96 (96.00%)
Nausea/vomiting	84 (84.00%)
Signs	
Tender Rt. lower quadrant	96 (96.00%)
Rebound tenderness Rt. iliac fossa	88 (88.00%)
Pyrexia > 37.3 C°	68 (68.00%)
Investigation	
Leucocytosis $> 10 \times 10^9/L$	80 (80.00%)
Total Modified Alvarado score	
Mean ± SD	7.56±1.56
Median (min-max)	8 (4-9)
Total Modified Alvarado score	
< 6	16 (16.00%)
≥ 6	84 (84.00%)
Total Modified Alvarado score	
< 7	24 (24.00%)
≥ 7	76 (76.00%)

Regarding to abdominal ultrasonography, 68 patients (68%) had positive (+ve) ultrasound findings for acute appendicitis but 32 patients (32%) had negative (-ve) findings. 80 patients (80%) were positive for histopathological study but 20 patients (20%) were negative, as shown in Table (3) and fig. (1). There were insignificant difference between males and females regarding to modified Alvarado score as a diagnostic method in patients suffering from acute appendicitis at < 6 and ≥ 6 also at < 7 and ≥ 7 ($P = 0.09$ and 0.87 respectively). But there were significant increase in diagnostic accuracy of abdominal ultrasound and histopathology in males in comparison to females ($P = 0.008$ and 0.003 respectively), as shown in Table (4).

Table 3. Investigations of studied populations

Variable	Summary statistics
Laboratory	
WBCs	
Mean ± SD	13004±3809
Median (min-max)	12600 (6200-19400)
Radiology	
Abdominal ultrasonography	
Negative	32 (32.00%)
Positive	68 (68.00%)
Histopathology	
Negative	20 (20.00%)
Positive	80 (80.00%)

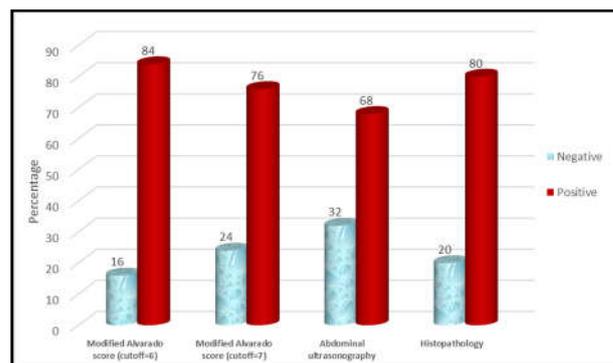


Fig. 1. Diagnosis of appendicitis by Modified Alvarado score, Abdominal ultrasonography and Histopathology

Table 4. Comparison between males and females as regard to different diagnostic methods

Variables	Females N=68	Males N=32	P value
Total Modified Alvarado score			
< 6	8 (25.00%)	8 (11.76%)	0.09
≥ 6	24 (75.00%)	60 (88.24%)	
Total Modified Alvarado score			
< 7	8 (25.00%)	16 (23.53%)	0.87
≥ 7	24 (75.00%)	52 (76.47%)	
Abdominal ultrasonography			
Negative	16 (50.00%)	16 (23.53%)	0.008
Positive	16 (50.00%)	52 (76.47%)	
Histopathology			
Negative	12 (37.50%)	8 (11.76%)	0.003
Positive	20 (62.50%)	60 (88.24%)	

As regard to operative details, acute suppurative appendicitis were the commonest operative findings (36%), followed by acute catarrhal appendicitis (28%), then gangrenous and normal appendix (12% for each), while perforated appendix (8%) and lastly appendicular abscess (4%). Operative management was done by appendectomy without drain in 72 patients (72%) and appendectomy with drain in 28 patients (28%). In patients suffering from appendicular abscess (4 patients) the appendix was resectable and treated by appendectomy with drain. The length of hospital stay ranged from 1-10 days with mean 2.52, as shown in Table (5) and fig.(2). Regarding to postoperative complications, wound infection, chest infection and vomiting were the commonest complications among studied populations (12% for each), followed by abdominal distension (8%) and lastly wound hematoma and wound dehiscence (4% for each), as shown in Table (6) and fig. (3).

Table 5. Distribution of operative details among studied populations and length of hospital stay

Variable	Summary statistics
Intraoperative diagnosis	
Normal	12 (12.00%)
A cute catarrhal appendicitis	28 (28.00%)
A cute suppurative appendicitis	36 (36.00%)
Gangrenous appendicitis	12 (12.00%)
Perforated appendicitis	8 (8.00%)
Appendicular abscess	4 (4.00%)
Operative maneuvers done	
Appendectomy without drain	72 (72.00%)
Appendectomy with drain	28 (28.00%)
Drainage of pus without removal of appendix	0
Rt. Hemi colectomy	0
Length of hospital stay /days	
Mean ± SD	2.52±1.76
Median (min-max)	2 (1-10)

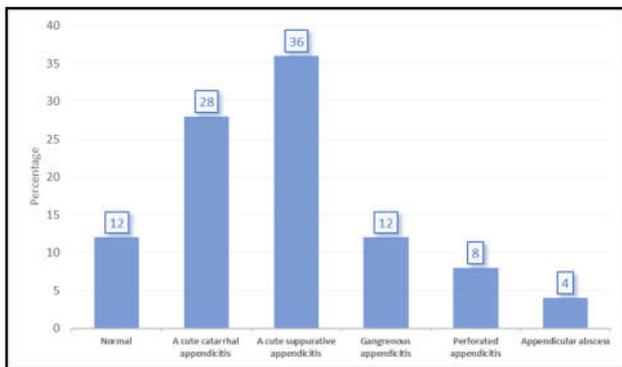


Fig. 2. Intraoperative findings of studied populations

Table 6. Distribution of post-operative complications among studied populations

Variable	Summary statistics
Wound infection	12 (12.00%)
Wound hematoma	4 (4.00%)
Wound dehiscence	4 (4.00%)
Abdominal distension	8 (8.00%)
Fecal fistula	0
Chest infection	12 (12.00%)
Vomiting	12 (12.00%)
Re-exploration	0
Death	0

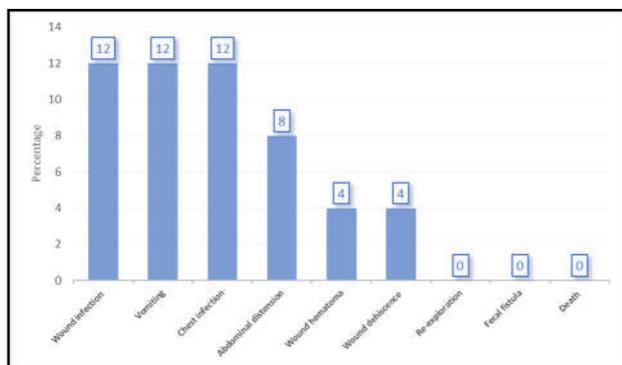


Fig. 3. Distribution of post-operative complications among studied populations

As regard to abdominal ultrasonography in comparison to histopathological study, 68 patients shows +ve ultrasound findings for acute appendicitis, 48 of them shows +ve histopathological reports known as true positive and the remaining 20 patients shows -ve histopathological reports

known as false positive, while 32 patients shows -ve ultrasound findings for acute appendicitis but shows +ve histopathological reports known as false negative. The ultrasound sensitivity= 60.00%, specificity= 0%, positive predictive value (PPV)= 70.59%, negative predictive value (NPV)= 0% and accuracy= 30%, as shown in Table (7).

Table 7. Sensitivity, specificity, positive predictive value, negative predictive value and accuracy of ultrasonography compared to histopathology

		Histopathology		Total
		Positive	Negative	
Abdominal Ultrasonography	Positive	(48) True positive	(20) False positive	68
	Negative	(32) False negative	(0) True negative	
	Total	80	20	100
Sensitivity = 60.00%				
Specificity = 0%				
Positive predictive value = 70.59%				
Negative predictive value = 0%				
Accuracy =30.00%				

Regarding to modified Alvarado score at cutoff point = 6, 84 patients were positive, 72 patients of them were true positive (Both MASS and histopathological reports were +ve), while the remaining 12 patients were false positive (MASS were +ve but histopathological reports were -ve). 16 patients shows MASS -ve, 8 patients of them shows false negative (MASS were -ve but histopathological reports were +ve) and the other 8 patients were true negative (Both MASS and histoathological reports were -ve). Modified Alvarado scoring system at cutoff point= 6 shows, sensitivity = 90%, specificity = 40%, PPV = 85.71%, NPV = 50% and accuracy = 65%, as shown in Table (8) and fig. (4).

Table 8. Sensitivity, specificity, positive predictive value, negative predictive value and accuracy of Modified Alvarado score (cutoff point=6) compared to histopathology

		Histopathology		Total
		Positive	Negative	
Modified Alvarado score (cutoff point=6)	Positive	(72) True positive	(12) False positive	84
	Negative	(8) False negative	(8) True negative	
	Total	80	20	100
Sensitivity = 90.00%				
Specificity = 40%				
Positive predictive value = 85.71%				
Negative predictive value = 50.00%				
Accuracy =65.00%				

Table 9. Sensitivity, specificity, positive predictive value, negative predictive value and accuracy of Modified Alvarado score (cutoff point=7) compared to histopathology

		Histopathology		Total
		Positive	Negative	
Modified Alvarado score (cutoff point=7)	Positive	(68) True positive	(8) False positive	76
	Negative	(12) False negative	(12) True negative	
	Total	80	20	100
Sensitivity = 85.00%				
Specificity = 60%				
Positive predictive value = 89.47%				
Negative predictive value = 50.00%				
Accuracy =72.50%				

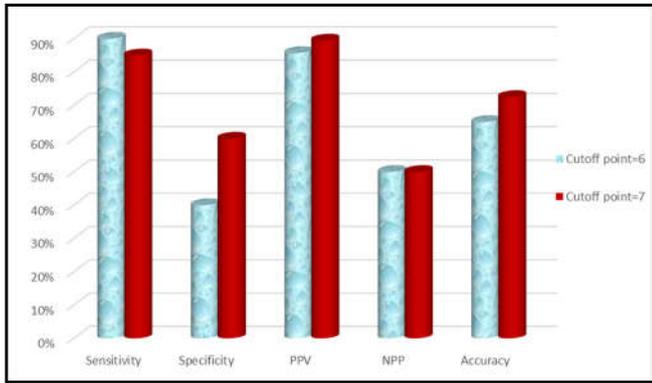


Fig. 4 Modified Alvarado score with cutoff points of 6 and 7

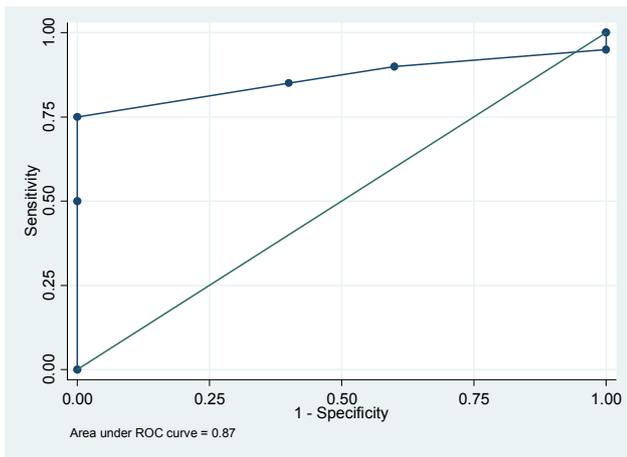


Fig. 5. ROC curve for diagnosis of acute appendicitis according to Modified Alvarado score



Fig. 6. Acute catarrhal appendicitis (Open appendectomy)



Fig. 7. Acute suppurative appendicitis (Open appendectomy)



Fig. 8. Perforated appendix (Open appendectomy)



Fig. 9. Gangrenous appendix (Lap. appendectomy)

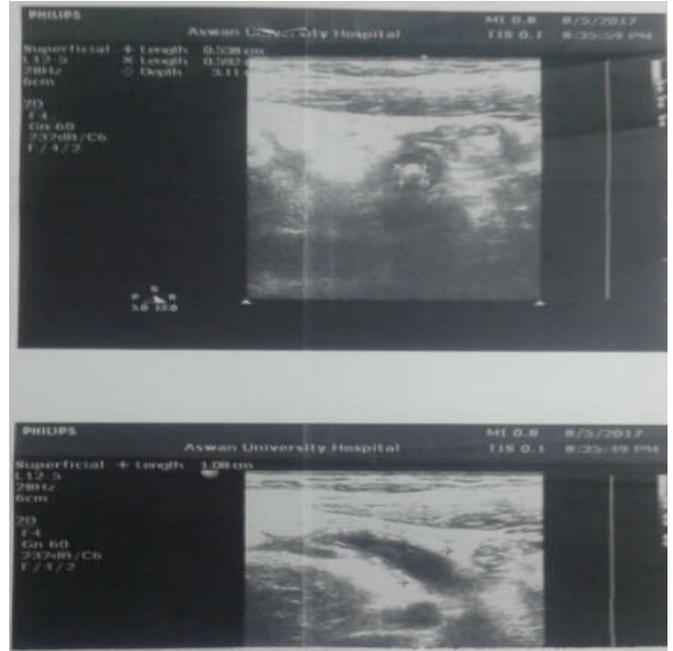


Fig. 10. Abdominal ultrasound showing acute appendicitis

Regarding to modified Alvarado score (cut of point = 7), 76 patients were positive, 68 of them were true positive (Both MASS and histopathological reports were +ve), while the remaining 8 patients were false positive (MASS were +ve but histopathological reports were -ve). 24 patients shows MASS -ve, 12 patients of them shows false negative (MASS were -ve but histopathological reports were +ve) and the other 12 patients were true negative (Both MASS and histoathological report were -ve).

Table 10. Modified Alvarado score (cutoff point=7) versus histological finding in different age group

Modified Alvarado score	Histopathology						Total
	No appendicitis			Appendicitis			
	≤20	21-40	40-60	≤20	21-40	40-60	
<7	4 (100%)	8 (66.67%)	0	4 (16.67%)	8 (18.18%)	0	24
≥7	0	4 (33.33%)	4 (100)	20 (83.33%)	36 (81.82%)	12 (100%)	76
Total	4 (100%)	12 (100%)	4 (100%)	24 (100%)	44 (100%)	12 (100%)	100

Table 11. Sensitivity, specificity, positive predictive value, negative predictive value and accuracy of Modified Alvarado score (cutoff point=7) compared to histopathology by sex

Sex	Sensitivity	specificity	PPV	NPP	Accuracy
Male	86.67	100	100	50	93.33
Females	80.00	33.33	66.67	50	56.67

Modified Alvarado scoring system at cutoff point=7 shows, sensitivity = 85%, specificity = 60%, PPV = 89.47%, NPV = 50% and accuracy = 72.50%, as shown in Table (9) and fig.(4) Receiver operating characteristic curve (ROC) for diagnosis of acute appendicitis according to Modified Alvarado Scoring System:- Area under the curve (AUC) = 0.87, standard error =0.034 and confidence interval (CI) (0.80-0.93). Both MASS and histopathological positive reports were more prevalent among all age groups at cutoff point ≥ 7 than at cutoff point < 7 , as shown in Table (10). MASS at cutoff point = 7 shows more Sensitivity, specificity, positive predictive value, negative predictive value and accuracy in males (86.67, 100, 100, 50, 93.33 respectively) than females (80.00, 33.33, 66.67, 50, 56.67 respectively), as shown in Table (11).

DISCUSSION

Other studies reported that, the age incidence varies between 7 to 65 years, the maximum incidence of acute appendicitis was found in age group of 11-20 years (45.45%), followed by age group of 21-30 years (25.45%) and then age group of 31-40 years. Approximately, 70% of the affected patients are in 2nd and 3rd decade of life (Singh *et al.*, 2014). Also others, found that the maximum incidence of 67% in 2nd and 3rd decade of life (Talukder *et al.*, 2009; Kailash *et al.*, 2008). In our study, the age incidence varies between 12 to 47 years, the maximum incidence of acute appendicitis was found in age group of 21-40 years (56%), followed by age group of ≤ 20 years (28%) and then age group of 41-60 years (16%). Approximately, 84% of the affected patients are in 2nd to 4th decade of life. Other researches, reported that, males were more than females in the incidence of acute appendicitis (58.18% and 41.81% respectively), with male to female ratio was 1.39: 1 (Singh *et al.*, 2014).

This concurs with our results, the incidence of acute appendicitis were more in males than females (68% vs 32%) with a ratio of 2.13:1. But other investigators, documented different results in which that male: female ratio was 1: 1.66 (Mardan *et al.*, 2007). Ultrasonography is an affordable, noninvasive tool whose results can be obtained more quickly than for C T scans (Incesu *et al.*, 1997). Many studies proved that, ultrasound has a high sensitivity ranged from 55% to 98% and specificity ranged from 50% to 100%, PPV ranged from 80.48% to 97.4, NPV ranged from 19.51% to 89.19% and accuracy ranged from 70.91% to 81%. These results emphasize that appositive ultrasonographic findings for appendicitis is strongly in favor of a diagnosis of acute appendicitis.

However a negative ultrasound findings is not sufficient to rule out the diagnosis and discharge the patient (Singh *et al.*, 2014; Incesu *et al.*, 1997; Flum *et al.*, 2002; Nasiri *et al.*, 2012). But in our study, ultrasound sensitivity= 60%, specificity= 0%, PPV= 70.59%, NPV= 0% and accuracy= 30%, comparing our results with the previous results reveals that the ultrasound provides less reliable findings for the diagnosis of acute appendicitis in our study. These variations in reported data may be due to that, the ultrasound is an operator- dependent technique and the results vary depending on how is performing the ultrasonography, also the variations in results may be due to differences in sample size, applied statistical techniques of various studies or physician experience. Other investigators found that, ultrasound was significantly more in women than in men (95% vs 71%) (Nasiri *et al.*, 2012). In contrast to this results, our study, shows that ultrasonography was significantly increased in men than in women (76.47% vs 50%, P= 0.008) in diagnosis of acute appendicitis.

Modified Alvarado scoring system (MASS) has been shown to be a quick and inexpensive diagnostic tool in patients suspected of suffering from acute appendicitis. However, different accuracies have been reported for the MASS in different studies (Flum *et al.*, 2002; Horzic *et al.*, 2005; Old *et al et al.*, 2005). Other researches found that, the most common MASS parameter was right lower quadrant tenderness (85.3%), and the only factor whose correlation with acute appendicitis was statistically significant was nausea and /or vomiting (Nasiri *et al.*, 2012). This concurs with our results, the most common MASS components was tender Rt. lower quadrant (96%) and also anorexia (96%), followed by rebound tenderness Rt. iliac fossa (88%), then nausea/vomiting (84%), leucocytosis (80%) and lastly fever and migrating Rt. iliac fossa pain (68% for each).

In some studies, MASS at cutoff point = 7, sensitivity 65.7%, specificity 37.5%, PPV 89.8%, NPV 11.5% and accuracy 62.7%. Choosing the cutoff point =6, sensitivity 85.1%, specificity 25%, PPV 90.5%, NPV 16.7% and accuracy 78.7%. Regarding to these findings, it appears that a cutoff point of 6 for the MASS could be appropriate (Nasiri *et al.*, 2012). Also other studies, reported that. MASS at cutoff point = 7, sensitivity 82.05%, specificity 25%, PPV 91.42%, NPV 65% and accuracy 81.82% (Singh *et al.*, 2014). Alamgir, *et al.*, reported the finding of sensitivity (94.14%) and specificity (66.66%) and PPV (83%) (Almgir *et al.*, 2009). Pairat Srasorn, documented sensitivity, specificity and PPV of 98%, 92% and 95% respectively in their series of study (Pairat., 1993).

Also Davis, *et al.*, found that PPV and NPP of 82% and 62% (David *et al.*, 1993). This nearly agree with our results, MASS at cutoff point = 6, sensitivity 90%, specificity 40%, PPV 85.71%, NPV 50% and accuracy 65%. Also MASS at cutoff point = 7, sensitivity 85%, specificity 60%, PPV 89.47%, NPV 50% and accuracy 72.50%. These results emphasize that MASS at cutoff point =7 is more accurate in diagnosis of acute appendicitis than at cutoff point =6. Also MASS has already been proved to have a high sensitivity, specificity, PPV and accuracy in the diagnosis of acute appendicitis more than abdominal ultrasonography.

Other investigator reported that, Receiver operating characteristic curve (ROC) for diagnosis of acute appendicitis according to the MASS, the area under the curve (AUC) is 0.837 with standard error of 0.67 and confidence interval (CI) of 0.705- 0.968 (Nasiri *et al.*, 2012). In our study, ROC curve for diagnosis of acute appendicitis according to MASS:- AUC = 0.87, standard error =0.034 and CI = 0.80-0.93. Both modified Alvarado score and histopathological positive reports were more prevalent among all age groups at cutoff point ≥ 7 than at cutoff point < 7 . Modified Alvarado score at cutoff point = 7 shows more Sensitivity, specificity, positive predictive value, negative predictive value and accuracy in males (86.67, 100, 100, 50, 93.33 respectively) than females (80.00, 33.33, 66.67, 50, 56.67 respectively). Other studies reported that, histopathological examination confirmed appendicitis in 66.9% and normal appendix giving a negative appendectomy rate of 33.1%. Being 26.8% and 38.3% for male and female respectively (Ojo *et al.*, 1991). In our study, +ve histopathological reports = 80% (appendicitis) and -ve HPR = 20% which considered as normal appendix giving negative appendectomy rate of 20%. Being 11.76% and 37.50% for male and female respectively.

The negative appendectomy rate in the present study were found to be higher in females than males, this is because of misdiagnosis may have occurred in females of reproductive age group where other pelvic diseases could make diagnosis difficult. In such cases MASS should be complemented with diagnostic procedures like laparoscopy or imaging such as ultrasound, CT scan or MRI to minimize the rate of negative appendectomy (Gilmore *et al.*, 1975). Negative appendectomy rate was 15% to 30% in other researches (Gokce *et al.*, 2011). This agree with our results in which negative appendectomy rate was 20%. The rate of perforated appendix in other studies was 9.4% (Asefa., 2000). However, much higher perforation rates have been reported from some centers in Nigeria (Naaeder *et al.*, 1999). In developing countries, rates of between 6-65% have been quoted (Adesunkanmi *et al.*, 1998). In our study, the rate of perforated appendix was 8% and most of them occurred in patients with MASS ≥ 7 . Delayed presentation, fulminate disease, misdiagnosis or failure to accept surgical treatment are contributory factors to high perforation rates. Perforation rates are much higher in the very young and the elderly, where the diagnosis is often difficult leading to perforation rates as much as 80% in some reported series (Horatas *et al.*, 1990).

Other reports documented that, the duration of illness in majority of patients was four days. The majority of patients reported to the hospital and seen by the admitting doctor in more than 24 hours after the onset of illness (Ohmann *et al.*, 1995). In this study, the length of hospital stay ranged from 1-10 days with median 2 days and mean \pm SD = 2.52 \pm 1.76.

The reason for delay in seeking medical consultations in this study may be attributed to delay in referral from peripheral hospital, lack of money to pay for the medical services, also may be due to misdiagnosis or fear of surgery so they are treated conservatively with analgesics and antibiotics to mask the symptoms. Delayed presentation is associated with increased morbidity and mortality due to perforation of the appendix and peritonitis. Wound infection was the commonest postoperative complications represent 12%, this may be due to that the appendicular wounds are potentially septic.

Conclusion

From the present study, it is concluded that modified Alvarado scoring system is a better diagnostic tool than ultrasonography alone in diagnosis of acute appendicitis because of the MASS provides high degree of sensitivity, specificity, PPV, NPV and accuracy in diagnosis of acute appendicitis in relation to histopathological study. MASS has to be more helpful in male patients by showing lower negative appendectomy rate and high sensitivity, specificity, PPV and accuracy for male patients as compared to females. But still neither MASS nor ultrasonography is absolute tool in reducing negative appendectomy in patients of suspected appendicitis. Although, abdominal ultrasonography alone has higher rate of negative appendectomy than MASS so positive ultrasonography can be prerequisite for appendectomy in patients with suspected appendicitis, it can be only complimentary to clinical course or clinical judgments.

Recomindation

MASS should be used to improve the diagnostic accuracy of acute appendicitis and subsequently reduce negative appendectomy and complication rates. MASS > 7 should indicate appendectomy without the need for further imaging. The use of MASS in female patients for diagnosis of acute appendicitis should be supplemented by additional investigations like abdominal ultrasound, CT scan, MRI or laparoscopy.

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Conflicts of Interest

There are no conflicts of interest.

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