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Diagnostic Accuracy of Modified Alvarado Score and Pelvi-Abdominal Ultrasound in Diagnosis of Acute Appendicitis

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ABSTRACT

Background: Acute abdominal pain is the main complaint in about 9% of emergency visits. The surgical etiology is more expected with the presence of manifestations like fever, absent sounds of the bowel, vomiting/diarrhea, guarding, abdominal rigidity and rebound tenderness. The diagnosis is usually associated with patient's age. The current work aimed to evaluate diagnostic accuracy of modified Alvarado Scoring system (MASS) and pelvi-abdominal ultrasound in diagnosis of acute appendicitis.

Patients and Methods: This prospective observational study, included 50 patients. They were selected from attendee of general surgery clinics, Al-Azhar University Hospitals, Minya-El-Qmah Hospital and Kafr Saqr Hospital. The study completed between September 2023 and March 2024.

Results: There was a statistically significant proportional correlation between pathology and MASS, while there was a statistically significant negative correlation between pathology with sensitivity of ultrasound. MASS had higher sensitivity (87.5%) and specificity (64.7%) than ultrasound for diagnosis of appendicitis.

Conclusion: MASS is considered as a good diagnostic tool for acute appendicitis in different ages. Both of MASS and Ultrasound should be used as predictors of acute appendicitis. This will lead to the reduction of negative appendectomy with subsequent reduction of morbidity and mortality.

Keywords: Modified Alvarado Score; Pelvi-Abdominal Ultrasound; Acute Appendicitis.

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INTRODUCTION

Acute abdominal pain is responsible for ~ 9% of emergency visits. The surgical etiology is more expected with the presence of certain clinical manifestations (e.g., fever, nausea and/or vomiting, diarrhea, silent bowel, voluntary guarding, abdominal rigidity and specifically rebound tenderness). The age of the patient may help in the differential and prediction of proper diagnosis. For example, gastroenteritis, urinary tract infections, pulmonary infections and colitis are more expected in the school-age children. Otherwise, in female adolescents, the gynecological causes are more expected. However, the commonest surgical etiology is the acute appendicitis among children and adolescents [1-3].

From the pathophysiological point of view, appendicitis is described as a process of five stages. These stages usually completed within 24 to 36 hours. The first stage is the obstruction and distension of the appendiceal lumen due to inability to drain. The etiology is multifactorial and widely different. The commonest causes include lymphoid hyperplasia, foreign body, parasitic infestations, fecaliths and malignancy. The site of obstruction can occur at any segment of the appendix from the tip to colic junction [4-6].

The second stage is best described by its manifestation of neurogenic pain. It is due the stimulation of the afferents of the 8^{th} to 10^{th} thoracic nerves. The pain is of mild to moderate severity, located at the peri-umbilical regions and typically last for 4- 6 hours [7].

The third stage is the ischemic stage due to reduction of appendiceal wall perfusion due to continuous increase of the intra-luminal pressure. In this stage, bacteria are able to invade the wall leading to the development of transmural inflammation [the fourth stage]. The fifth stage is the gangrenous or perforated appendix [8].

The diagnosis of acute appendicitis is usually based on the clinical basis (history and physical examination). The classic manifestations include the peri-umbilical pain or colic. This pain will shift to the right iliac fossa and the anorexia or nausea are usually associated with this pain. In addition, other manifestations include fever, tenderness at the right iliac fossa, guarding and rebound tenderness [9-11]. However, there was a higher rate of negative appendicitis when based on clinical examination. Thus, the need for more accurate diagnosis pushed researchers to develop new aids (e.g., ultrasound and different scores).

Alvarado scoring system was first described and named after Alfredo Alvarado in 1980s. Then modified by Kalan and his associates. The original score composed of three signs, three symptoms and two laboratory elements with a total score of 10. The modified system included only one laboratory element with a total score of 9. A score of 7 or higher is considered of high probability for the diagnosis of acute appendicitis [12-14]. Ultrasound is considered as a helpful tool to support clinical diagnosis of acute appendicitis especially in uncertain cases. It is readily available, non-invasive and cheap modality with considered rate of accuracy (70-95%) [15].

The main ultrasound criteria to diagnose acute appendicitis include blind-ended, non-compressible, a peristaltic tube, with a diameter of more than 6 mm, arising from the tip of cecum with a gut signature. However, if an appendicolith was discovered, it is a positive test regardless of the diameter of the appendix [16]. The sure diagnosis of appendicitis is carried out by the histopathology of surgical specimens. It includes neutrophilic infiltration of the muscularis propria. This confirms the clinical pre-operative diagnosis and exclude missed one [1].

The objective of this study was to evaluate diagnostic accuracy of modified Alvarado Scoring system (MASS) and pelvi-abdominal ultrasound in diagnosis of acute appendicitis.

PATIENTS AND METHODS

This prospective observational study, included 50 patients were selected from attendee of general surgery clinics of Al Azhar University Hospitals, Minya El-Qmah Hospital and Kafr Saqr Hospital, Samples collected randomly from September 2023 to March 2024.

Inclusion criteria included all patients above 18 years, of both sexes, who were submitted for suspected acute appendicitis with lower abdominal pain or right iliac fossa pain, and give informed consent.

Exclusion criteria included swelling of the right iliac fossa, generalized peritonitis, and other gynecological or urological causes of acute abdomen, previous surgery on the right iliac fossa, immune-deficiency or immune therapy and history of abdominal radiotherapy.

All patients were subjected to complete history taking, a full clinical examination, laboratory investigations (CBC, Serum creatinine, liver enzymes, Random blood sugar and INR), radiological workup (Pelvi-abdominal Ultrasound) and calculation of Modified Alvarado Scoring System (MASS) [17]. It consisted of three symptoms (each score 1 if present), three signs and one laboratory element. The symptoms include 1) migratory right iliac fossa pain, nausea/vomiting, and anorexia. The signs include 1) tenderness in the right iliac fossa (scored 2 if present), rebound tenderness in the right iliac fossa and elevated temperature (each scored 1 if present) and the leukocytosis (scored 2 if present) as the laboratory element. The total score is 9, and score equal to or above 7 is considered an indicator of acute appendicitis (positive).

The laboratory workup consisted of complete blood count (leukocytosis is an indication of positive appendicitis), C-reactive protein (elevated levels indicate inflammation), liver enzymes, random blood sugar, INR and urine analysis to exclude urinary tract infection.

Pelvi-abdominal ultrasound was performed to assess the tenderness on probing in the right iliac fossa. In addition, it detects the presence of any collections in the right iliac fossa or pelvis. Also, it looks for any thickening of the appendiceal wall, a prominent feature of a congested appendix and to exclude any concomitant urological gynecological finding e.g. ureteric stones, tubal pregnancy or ovarian cyst.

The following definitions were used for clinical manifestations.

Abdominal Pain: Typically started around the umbilicus and then migrated to the right lower quadrant (RLQ). The pain may be sharp and intense.

Rebound Tenderness was determined from the following:

Guarding: Tensing of abdominal muscles in response to palpation.

Localized Tenderness: Pain or discomfort felt upon palpation of the RLQ.

Rovsing's Sign: Pain felt in the RLQ when pressure was applied to the left lower quadrant.

Psoas Sign: Pain elicited when extending the right hip, suggesting irritation of the psoas muscle by an inflamed appendix.

The intraoperative diagnosis was performed for 50 patients with postoperative histopathological study for all cases. Values of MASS was correlated with other variables, with histopathology as the gold-standard. In addition, calculation of operative time, duration of hospital stay and any complications were documented. Finally, the sensitivity of ultrasound and MASS were calculated according to the histopathological diagnosis.

Statistical Analysis:

The collected data were coded, processed, and analysed using SPSS program for windows, version 25 (IBM® Inc., Armonk, USA). Descriptive statistics were calculated for continuous variables. These measurements included means, standard deviations (for normally distributed data), and ranges (Minimum – Maximum). In addition, the qualitative variables were summarized by their frequencies and percentages. The Pearson correlation coefficient "*r*" was calculated and finally, receiver operation characteristic (ROC) curve was built to estimate sensitivity and specificity of ultrasound and MASS on the basis of histopathological results. A p value below 0.05 was considered statistically significant. Sensitivity could be defined as the percentage of true positive (e.g., 95% sensitivity = 95% of patients who have the target disease will test positive). On the other hand, specificity defined as the percentage of true negatives (e.g. 90% specificity indicates that, 90% of people who do not have the target disease will test negative). Both do not depend on disease prevalence. Positive predictive value (PPV) and negative predictive value (NPV) are directly related to the prevalence of the disease and permit clinical decision of how likely a patient has a specific disease. Thus, PPV indicates the probability of having disease when the test is position. Area under the curve is an estimate of the clinical value of the test in diagnosis of the disease (AUC ≥0.9 indicates excellent, values ≥ 0.8 and < 0.9 indicate good test) then lower values indicate lower power of the test.

RESULTS

The patient demographics and clinical manifestation were recorded in table (1). The patient age ranged between 18 and 70 years and the mean age was 29.2 years. The majority were females (60.0%). McBurney and rebound tenderness signs were reported in all cases, while 98% had pain migration and the psoas sign was the least reported sign (80.0%).

Vital signs and laboratory investigations were reported in table (2). The mean blood pressure was (114.2±9.06/ 75.2±6.46 mmHg), while heart rate ranged between 70 and 110 beats/minute and respiratory rate ranged between 14 and 22 cycles/minute.

In addition, total leucocyte count ranged between 4.6 and 18.5 x 10^3/ml and haemoglobin concentration ranged between 9.5 and 17.6 mg/dl. Other laboratory values were in normal levels. The MAAS calculation revealed that, 86% of patients were of high risk (values equal to or more than 7) and 14% were of intermediate risk (below 7). The results of ultrasound showed appendicitis among 82% and normal appendix in 18%.

Regarding correlation between TLC and temperature, there was mild, proportional significant correlation with each of temperature and pathology (Table 3). In addition, there was positive, moderate, significant correlation between pathology and MASS, but the correlation with ultrasound sensitivity was negative and slightly moderate and significant (Table 4).

Building the ROC curve, revealed that There was positive, moderate, significant correlation between pathology and MASS, but the correlation with ultrasound sensitivity was negative and slightly moderate and significant (Table 4)., MASS is more accurate than ultrasound in diagnosis of acute appendicitis (the area under the curve was 0.761 and 0.715 for MASS and ultrasound, respectively). The MASS sensitivity and

specificity was 87.5% and 64.7% respectively, while the sensitivity and specificity of ultrasound was 81.5% and61.0% respectively (Table 5, Figure 1).

Table (1): Demographic data and clinical manifestations among study group

Variable	Measures	Values
Age (years)	Mean±SD	29.2 ± 11.7
	Min. – Max.	18-70
Gender (n, %)	Male	20(40)
	Female	30(60)
Migration of pain (n, %)		49 (98)
Anorexia (n, %)		44 (88)
Nausea (n, %)		44 (88)
Vomiting (n, %)		41(82)
McBurney Tenderness (n,%)		50 (100)
Rebound Tenderness (n, %)		50 (100)
Rovsing's sign (n, %)		47 (94)
Psoas sign (n, %)		40 (80)

Table (2): Vital Signs in the studied group and Laboratory investigations among study group

Variable		Values	
		Mean±SD	Min. – Max.
Vital signs	Systolic blood pressure (mmHg)	114.2 ± 9.06	100-140
	Diastolic blood pressure (mmHg)	75.2±6.46	70-90
	Temperature (^{O}C)	37.86±0.39	37-38.7
	Heart rate (beat/minute)	87.28 ± 8.65	70 -110
	Respiratory rate (cycle/min)	17.3±2.07	14-22
Laboratory investigations	Total leucocyte count (x10^3/ml)	10.8 ± 4.06	4.6-18.5
	Hemoglobin concentration (g/dl)	12.5 ± 1.5	9.5-17.6
	Platelet count (x10^3/ml)	275.2 ± 75.2	133-530
	INR	1.13±0.1	133-530
	Serum creatinine (mg/dl)	0.9 ± 0.2	0.5-1.4
	Random blood sugar (mg/dl)	101.4 ± 10.2	80-122
	Alanine transaminase (U/L)	20.7 ± 5.9	10-33
	Aspartate transaminase (U/L)	24.9 ± 7.8	15-63

Table (3): correlation between Total Leucocyte Count (TLC), Temperature and Pathology in the studied group.

Total leucocyte count		
	r	**P value**
Temperature	0.482	<0.001
Pathology	0.525	<0.001

Table (4): correlation between Pathology, Sensitivity of ultrasound and Modified Alvarado score (MAS) in the study group.

	Pathology	
	r	**P value**
Sensitivity of ultrasound	-0.321	0.02
Modified Alvarado score	0.520	<0.001

Table (5): sensitivity and specificity of MASS and Ultrasound in diagnosis of acute appendicitis with histopathology as the gold standard.

	AUC	Sig.	95% CI	Sensitivity	Specificity
MASS	0.761	0.003	0.694 - .900	87.5%	64.7%
Ultrasound	0.715	0.015	0.564 -.866	81.5%	62%

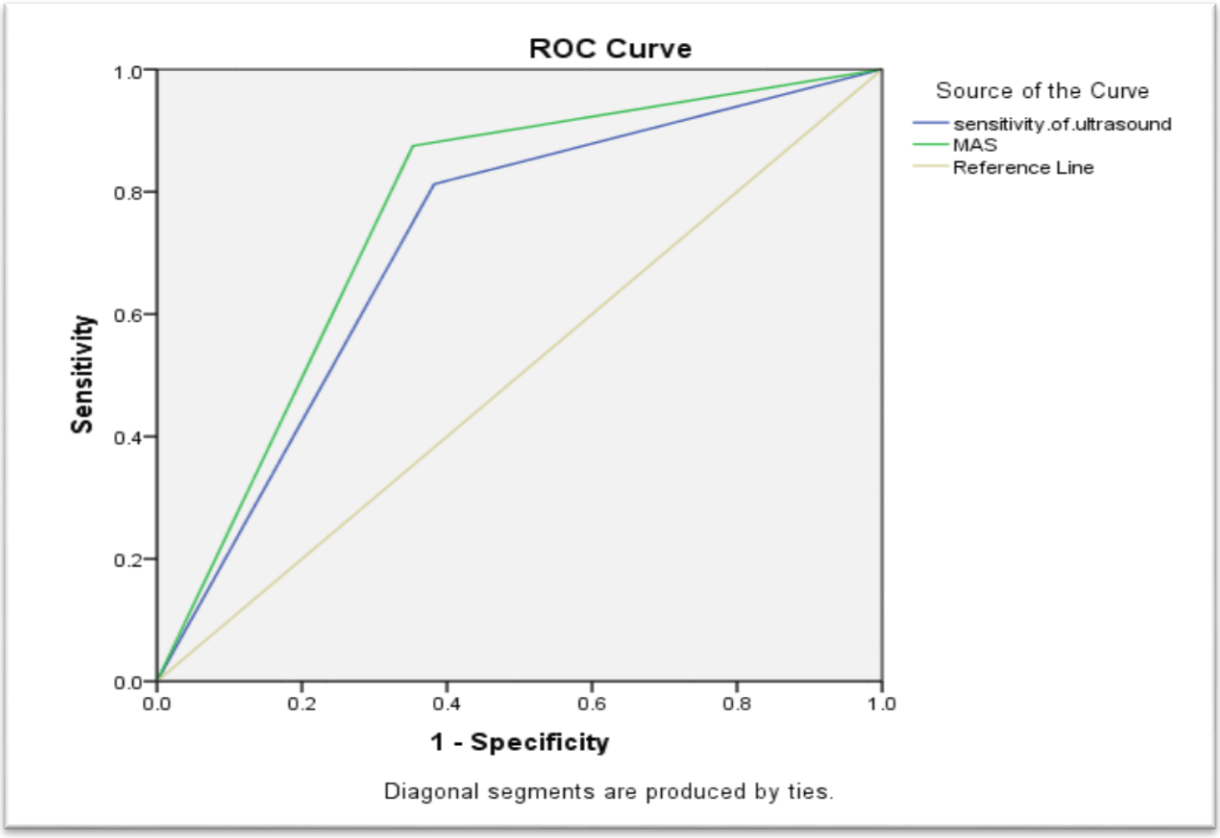

Figure (1): ROC curve of MASS and ultrasound for diagnoses of appendicitis

DISCUSSION

The present study revealed that the mean age of patients was 29.2 ± 11.7 years ranging between from 18 to 70 years, 40% of patients were male and 60% were females. Age and Range matched with that found by **Kansakar *et al.*** [18].

The age ranged from 15 to 50 years with the mean age was 27.41±7.14 years. Age and Sex distribution in line with **Ramez *et al.*** [17].

The mean age of patients was 27.54 ± 11.5 years, 30 (60%) patients were males and 20 (40%) patients females. Also, age range and sex distribution in consistent with **Bhardwaj *et al.*** [19]**.** The age ranged from 5 to 80 years, 33.33% were in the adolescent age group of 11 to 20 years, 73% of patients were males, and 26.81% of patients were females.

As well, Range and sex distribution in concordance with **Mishra *et al.*** [20]. They reported that 70% of patients were males and 30% of patients were females, their age ranged from 11 to 62 years and the majority of patients (42%) were in their third decade of age.

Regarding distribution of clinical picture among patients, the current study reported that all our studied population had McBurney's tenderness, Rebound Tenderness, 98% had Migration of pain, 44 (88%) Patients had Anorexia, and Nausea.

These results in consistent with **Kansakar *et al.*** [18]**.** Who demonstrated that Nausea/vomiting was the most common symptom presented in 29 (90.62%) patients followed by anorexia presented in 28 (87.50%) patients, while right iliac fossa tenderness was the most common sign presented in all the 32 (100%) patients.

Similarly, our findings in line with **Bhardwaj *et al.*** [19]**.** Who revealed that pain in the right iliac fossa was the most common symptom and presented in all their studied patients followed by the clinical sign of tenderness in the right iliac fossa (97.8%), nausea and vomiting presented in 76% of patients.

As well, our study in agreement with **Ramez *et al.*** [17]**.** Who reported that Right Lower Quadrant tenderness (RLQ) as well as Rebound tenderness were present in all of the cases (100%), 48 (96%) patients had anorexia and 33 (66%) patients had Nausea and vomiting.

According to vital signs, the present study demonstrated that the mean heart rate was 87.28 ± 8.65, the mean systolic blood pressure was 114.2 ± 9.06 ranging from 100 to 140, the mean diastolic blood pressure was 75.2± 6.46 ranging from 70 to 90, the mean temperature was 37.86±0.39 ranging from 37 to 38.7 and the mean respiratory rate was 17.3±2.07 ranging from 14 to 22. As regards vital signs, our findings in line with **Bhardwaj *et al.*** [19] who demonstrated that 34% of their studied patients had fever while 66% of patients had normal temperature?

Regarding Modified Alvarado Score, the present study demonstrated that the mean Modified Alvarado Score was 7.7 ± 1.2 ranging from 5 to 9, 86% of patients with High risk and 14% with Intermediate risk.

Similarly, our study in consistent with **Ramez *et al.*** [17] who reported that the most frequent score of the patient was 10 in 14 cases, followed by 9 and 8, then 7. The majority of the studied cases (82%) was classified as high risk, 10% of studied cases classified as intermediate-risk and only 4 (8%) cases classified as low risk by total Alvarado score.

According to Modified Alvarado Score, our findings in line with **Kansakar *et al.*** [18] who demonstrated that 59.4% of patients MAS less than 7 and 40.6% of their studied population with High risk for acute appendicitis (MA S ≥7).

Regarding Ultrasonographic findings, our results showed that 82% of patients had appendicitis while 18% of patients had normal appendix in the studied group. The current study in consistent with **Kansakar *et al.*** [18] who reported that 23 (71.8%) patients had positive USG score (appendicitis) while 9 (28.2%) patients had negative score in USG (normal appendix).

Similarly, the present study in agreement with **Mishra *et al.*** [20]**.** Who demonstrated that 67% of their studied cases had appendicitis while 33% of cases had normal appendix regarding abdominal ultrasound findings.

According to laboratory investigations among our patients, the mean white blood cell (WBCS) was 10.8 ± 4.06, 58% of patients had increased level of white blood cell while 42% of patients had normal level of WBC, the mean Hemoglobin was 12.5 ± 1.5, the mean platelet was 275.2 ± 75.2, the mean INR was 1.13±0.1, the mean serum creatinine was 0.9 ± 0.2, the mean random blood sugar was 101.4 ± 10.2, the mean ALT was 20.7 ± 5.9, and the mean AST was 24.9 ± 7.8.

As regards laboratory investigations, our findings in line with **Bhardwaj *et al.*** [19] who reported that 66.66% of their studied population had increased level of white blood cell while 33.34% of patients had normal level of WBCs.

In addition, our results in consistent with **Ramez *et al.*** [17] who revealed that 68% of patients had increased level of white blood cell.

The present study reported that there was highly statistically significant positive correlation between severity of Total Leucocyte Count (TLC) with high temperature and pathology. Also, the current study revealed that there was highly statistically significant positive correlation between Pathology with Modified Alvarado score (MAS), while there was statistically significant negative correlation between Pathology with Sensitivity of ultrasound.

Similarly, **Ramez *et al.*** [17]. Evaluated Alvarado score according to the post-operative pathological assessment, they found that 37 (90%) patients with high-risk Alvarado score (7 or more) had appendicitis. Also, 4 (80%) patients with an intermediate-risk score of Alvarado score had appendicitis indicating that positive relation between Pathology and Modified Alvarado score.

According to ROC curve analysis of MAS and Ultrasound for diagnoses of appendicitis, the present study reported that Modified Alvarado score had higher sensitivity (87.5%) and specificity (64.7%) than ultrasound (81.5% and 62%) for diagnosis of appendicitis. As well, our findings in line with **Mishra *et al*.** [20] who revealed that the sensitivity of Modified Alvarado score had was (81.61%) and specificity was (61.54%). The sensitivity of ultrasound was 71.26% and specificity was 61.54% indicating that MAS had higher sensitivity for diagnosis of appendicitis when compared to ultrasound.

Also, our findings in line with **Bhardwaj *et al.*** [19]**.** Who reported that the diagnostic accuracy of MAS was 68.6%, sensitivity was 80.9% and specificity 57.1% while the diagnostic accuracy of abdominal ultrasound was 61.6%, sensitivity was 79.5%, and the specificity was 50%.

Similarly, our results agreed with **Ramez *et al.*** [17]. Who demonstrated that the sensitivity of Modified Alvarado score was 68.9% and the specificity was 40% which was lower than our findings.

Furthermore, the present study in consistent with **Rizk *et al.*** [1] who illustrated that the sensitivity of Modified Alvarado score was (96.0%) while the sensitivity of ultrasound (89.4%). In contrast, our results in disagreement with **Kansakar *et al.*** [18] who demonstrated that ultrasound had higher sensitivity (74.19%) and accuracy (75.0 %) as compared to Modified Alvarado score for diagnosis of appendicitis.

Conclusion:

MASS is a good diagnostic tool for acute appendicitis. In addition, MASS and pelvi-abdominal ultrasound should be used (in conjunction) to predict acute appendicitis. It increased the number of positive diagnosis and reduce the negative appendectomy. Thus, reduce the associated morbidity and mortality. However, the small sample size and short follow up durations are two limiting steps of the current study. In addition, absence of the comparison groups is another limiting steps. The results of the study should be explained with caution and future wide scale studies with comparison groups are warranted.

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None

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