

## The Efficiency of Modified Alvarado Scoring System in the Diagnosis Acute Appendicitis

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### ABSTRACT

**Background:** Acute appendicitis is one of the main pathological conditions requiring emergency surgical intervention. Many scoring methods have been applied to decrease the number of negative appendectomies. The aim of our study was to validate the efficiency of Alvarado scoring system in diagnosis of acute appendicitis. **Methods:** A prospective study was conducted on group of patients clinically diagnosed as acute appendicitis at Ain Shams University Hospital and was carried out on 150 patients in the period from March 2017 to February 2018. Data were collected and analyzed by the computer using IBM SPSS software package. **Results:** Our study included 92 male patients (61.3%) and 58 female patients (38, 6%) with (male: female) rate of (1.56: 1). Their mean age was  $(21.2 \pm 8.4)$ , ranging from 9-43 with a median of 19. All patients were carefully examined; rebound tenderness was noted in 99 patients (66%). Modified Alvarado score was calculated for each patient. In our study, we set a cut off value of  $MAS \geq 7$  and the overall specificity of the test at the score 7 was 52.94% (62.5% for males and 44.44% for females). **Conclusion:** The Alvarado score is a reliable, cheap, and reproducible diagnostic method which can be used by the primary care physician and the emergency room physician to evaluate a patient who presents with pain in the right lower abdominal quadrant.

**Keywords:** Appendicitis, appendectomy, Alvarado, scoring system

### INTRODUCTION

The surgical treatment of appendicitis is one of the great public health advances of the last 150 years. The most frequently performed emergency operation worldwide is appendectomy for appendicitis. Appendicitis is a disease of the young, with 40% of cases occurring in patients between the ages of 10 and 29 years. In 1886, Fitz reported the associated mortality rate of appendicitis, without surgical therapy, to be at least 67%. Currently, acute appendicitis with treatment, has a mortality rate of about 1%.

Many scoring systems have been applied to decrease the number of negative appendectomies, they include clinical, laboratory and ultrasound parameters in order to increase the security of diagnosis, e.g Teicher score (Teicher et al., 1983), Alvarado score (Alvarado, 1986), Fenyo score (Fenyo, 1987), Christian score (Christian et al., 1992), Ohman score (Ohman et al., 1995) and Tzanakis score (Tzanakis et al., 2005).

In 1986 Alvarado designated a scoring system which has been confirmed in adult surgical practice. This scoring includes 8 variables: 3 symptoms; (migrating pain from umbilicus to the right iliac fossa, anorexia and vomiting), 3 signs;

(tenderness, rebound tenderness and pyrexia) and 2 laboratory data (leukocytosis and shifting to the left of neutrophil maturation) yielding a total score of 10.

### PATIENTS AND METHODS

#### **Type of the study:**

A prospective study was conducted on group of patients clinically diagnosed as acute appendicitis at Ain Shams University Hospital and was carried out on 150 patients in the period from March 2017 to February 2018.

#### **Selection of patients:**

150 patients were selected from the admitted patients at the Department of Surgery at Ain Shams University Hospital. Patients clinically diagnosed with acute appendicitis.

#### **Inclusion criteria:**

Patients of all ages and both gender.

#### **Exclusion criteria:**

- Patients who had an obvious cause of abdominal pain on physical examination (e.g., penetrating trauma, postoperative pain), or those with history of appendectomy.
- Patients who had a BMI 40 or more.

- Patient with sub-acute appendicitis or chronic appendicitis.
- Pathologically diagnosed inflammatory bowel disease.
- Pathologically diagnosed malignant lesion.

**Methods:**

All patients were submitted to the following:

1. Clinical assessment.
2. Laboratory investigations.
3. Classification according to the modified Alvarado score.
4. Operative techniques and intraoperative assessment.
5. Postoperative pathological examination.

Clinical assessment:

1. Complete history taking.
2. Through clinical examination

Laboratory Investigation:

1. White blood cell count
2. Other investigations according to the patient's condition(24).

Classification according to Modified Alvarado Score:

According to their Modified Alvarado Score, patients were graded into three groups based on six clinical symptoms and one laboratory criteria each weighted by a coefficient on a score pad as follows:

**Table (1):** The modified Alvarado score for diagnosis of acute appendicitis

Features	Score
Symptoms	
Migratory right iliac fossa pain	1
Anorexia	1
Vomiting / Nausea	1
Signs	
Tenderness in the right lower quadrant	2
Rebound tenderness in the right lower quadrant	1
Pyrexia 37.5	1
Investigations	
Leucocytosis	2

NB: In the study, pyrexia is defined as oral temperature 37.5° and leucocytosis is defined as white blood cells count>10000/dl

According to the score, the patients can be grouped into three groups:

**Group (A): (score 1-4):**

These patients with negative u/s were discharged and sent home on antibiotic therapy with the instructions to come back to the hospital if symptoms recurred or the condition became worse.

**Group (B): (score 5-6):**

Hospital admission. These patients were reexamined and reassessed frequently, Their Modified Alvarado Score was recalculated again and they joined those of group (A) or those of group (C).

**Group (C): (score 7-9):**

These patients were prepared for urgent operative intervention.

**Operative management and intraoperative assessment:**

The decision to operate was made independently of the modified Alvarado Score and was based entirely on clinical judgment.

All cases were done edits by open laparoscopic technique.

**Postoperative Pathological Examination:**

The collected specimens from the patients subjected to surgical intervention have undergone histopathological examination, and so the patients were classified into four groups:

1. Negative (not appendicitis)
2. Catarrhal appendicitis.
3. Suppurative appendicitis
4. Complicated appendicitis

The diagnosis was established by both operative findings and histopathological examination of the appendectomy specimen(9). Literature indicates that a modified Alvarado score of 7 or more is highly suggestive of acute appendicitis(23). Based on this fact, this study considered a score of less than 7 as a negative result, while a score of 7 to 9 was considered positive.

These results were compared with the postoperative histopathological findings and therefore, we could evaluate the efficacy of the score(52).

**Statistical analysis of the data**

Data were fed to the computer and analyzed using IBM SPSS software package version 20.0. (Armonk, NY: IBM Corp) Qualitative data were described using number and percent(48). To verify the normality of distribution, the

Kolmogorov-Smirnov test was used and quantitative data were described using range (minimum and maximum), mean, standard deviation and median(48). Significance of the obtained results was judged at the 5% level.

The used tests were(69):

1 - Chi-square test

For categorical variables, to compare between different groups 2

2 - Fisher's Exact or Monte Carlo correction

Correction for chi-square when more than 20% of the cells have expected count less than 5

3- Student t-test

For normally distributed quantitative variables, to compare between two studied groups

4- Mann Whitney test

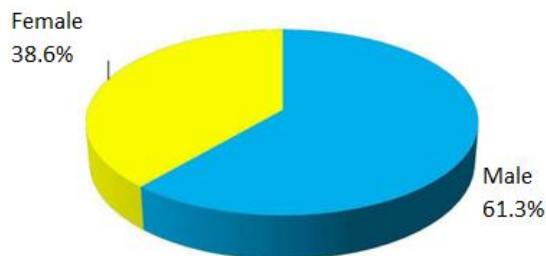
For abnormally distributed quantitative variables, to compare between two studied groups.

## RESULTS

### Patients Demography

The study included 92 male patients (61.3%) and 58 female patients (38, 6%) with (male: female) rate of (1.56: 1).

Their mean age was ( $21.2 \pm 8.4$ ), ranging from 9-43 with a median of 19.



**Figure (1):** Distribution of the patients according to sex.

### Clinical data of the patients:

The items used in the calculation of the Modified Alvarado score were gathered for all 150 patients and summarized in the following table:

**Table (2):** Distribution of the parameters of the modified Alavardo score among the studied patients:

	No.	%
Migrating pain	72	48
Anorexia	96	64
Nausea & vomiting	117	78
Tenderness	147	98
Rebound tenderness	99	66
Pyrexia > 375	99	66
Leucocytosis > 10000/dl	126	84

The previous table shows that tenderness was present in most of the cases (98%), followed by leukocytosis in (84%). The migrating pain was the least frequent symptom, present only in 48% of cases.

### Evaluation of patients using MAS:

All patients had been evaluated using MAS and their distribution was summarized in the following table:

**Table (3):** Distribution of the patients according to their MAS

Modified Alvarado score	No.	%
1	0	0
2	6	4
3	6	4
4	12	8
5	9	6
6	18	12
7	24	16
8	54	36
9	21	14
1 – 4 (group A)	24	16
5 – 6 (group B)	27	18
7 – 9 (group C)	99	66

In the previous table, it was clear that the most frequent score of the patient was 8, followed by 7 then 6. None of the patient had a score of 1 and only 4 patients had a score of 2 and other 4 patients had a score of 3.

According to the chosen cutoff point (MAS =7), the patients were divided into two categories:

1- 99 patients had MAS  $\geq 7$  (66%).

2- 51 patients had MAS  $< 7$  (34%).

**Evaluation according to the management:**

Of the entire group of 150 patients, 117 (78%) underwent surgery while 33 (22%) did not.

**Results of postoperative pathological examination:**

Histopathological examination of the removed specimens showed that the number of patients with established acute appendicitis was 96 (82%) and number of patients with normal appendices was 21 (14%).

According to the postoperative histopathological examination, 54 cases were catarrhal appendicitis, 25 were suppurative appendicitis and 17 were complicated appendicitis(83).

The results of postoperative histopathological examination were summarized in the following table:

**Table (4):** Distribution of the studied cases according to postoperative pathological assessment

Postoperative pathological assessment	%	No.
Not appendicitis	26	22.2
Acute appendicitis	91	77.7
Catarrhal appendicitis	49	41.8
Complicated appendicitis	17	14.5
Suppurative appendicitis	25	21.3

**Evaluation of MAS according to the postoperative results:**

The distribution of Alvarado scores for patients with appendicitis versus non-appendicitis patients is given in the following table:

**Table (5):** Distribution of the MAS among patients with acute appendicitis and those with normal appendix.

Modified Alvarado score	Appendicitis			
	Not appendicitis		Acute appendicitis	
	No.	%	No.	%
4	0	0	3	3.2
5	2	7.6	0	0
6	12	46.1	3	3.2
7	6	23	16	17.5
8	4	15.3	51	56
9	2	7.6	18	19.7
MCp	0.001*			
1 – 4 (group A)	0	0	3	3.2
5 – 6 (group B)	14	53	3	3.2
7 – 9 (group C)	12	46	85	93.4
MCp	0.001*			
4	0	0	0	0
4 – 6	14	53	6	6.5
≥ 7	12	46	85	93.4
FEp	0.001*			

P: p value for comparing between normal appendix and acute appendicitis MC: Monte Carlo test; Q: R: FE: Fisher Exact test; S: T: \*: Statistically significant at  $p \leq 0.05$

The previous table showed that the highest percentage of patients with proven acute appendicitis had a MAS of 8, while the highest percentage for those with normal appendix had a score of 6.

The distribution of the positive findings of parameters of MAS for patients with acute appendicitis and those with normal appendix is given in the following table:

**Table (6):** Distribution of the positive findings of parameters of MAS among operated patients.

Modified Alvarado score	Appendicitis				P
	No appendicitis (n = 26)		Acute appendicitis (n = 91)		
	No.	%	No.	%	
Migrating pain	15	57.5	60	65.9	X <sup>2</sup> p = 0.640
Anorexia	18	69.2	72	79.1	F <sub>E</sub> p = 0.526
Nausea & vomiting	24	92.3	78	85.7	F <sub>E</sub> p = 0.443
Tenderness	26	100	91	100	-
Rebound tenderness	20	76.9	73	80.2	F <sub>E</sub> p = 0.743
Pyrexia	21	80.7	72	79.1	F <sub>E</sub> p = 1.000
Leucocytosis	24	92.3	91	100	1.000

P: p value for Fisher Exact test

The previous table showed that 100% of cases of acute appendicitis and those that aren't acute appendicitis had tenderness. 100% of cases of acute appendicitis had leucocytosis and 92.3% of cases that weren't appendicitis had leucocytosis.

The least frequent manifestation was the migrating pain that was 65.9% in of cases of acute appendicitis and 57.5 % in cases that weren't appendicitis.

#### **Estimation of the performance of the MAS:**

According to this study, the performance of the score can be tested through calculating the overall sensitivity for MAS at the cutoff value of

$\geq 7$  which is 93.33 (94.59 for males and 91.30 for females), overall specificity which is 52.94 (62.5 for males and 44.44 for females), positive predictive value which is 87.5 and negative predictive value which is 69.23 and accuracy which is 84.42.

Overall negative appendectomy rate of the all studied cases is 22.07%.

Overall negative appendectomy rate at the cut-off value of MAS  $\geq 7$  is 12.5%; (7.8% in males and 19.2% in females).

These results are summarized in the following table:

**Table (7):** Evaluation of the results of the MAS among the studied patient.

Modified Alvarado score	Normal appendicitis	Acute appendicitis	Sensitivity	Specificity	PPV	NPV	Accuracy
Total	7	6	93.33	52.94	87.50	69.23	84.42
	$\geq 7$	85					
Male	7	4	94.59	62.50	92.11	71.43	88.89
	$\geq 7$	53					
Female	7	3	91.30	44.44	80.77	66.67	78.13
	$\geq 7$	31					

So, the MAS showed an acceptable sensitivity, specificity and accuracy at the chosen cut off value.

## **DISCUSSION**

In spite of the radical advances still in medical technology, appendicitis possesses a diagnostic challenge (Paulson et al., 2003).

The main aim of the clinician is to reach an accurate diagnosis in the fastest and most economical way possible, without subjecting the

patient to unnecessary surgery or investigations. Therefore, the ultimate goal in treating suspected appendicitis is to try to reduce the removal of a normal appendix without increasing the perforation rate (Paulson et al., 2003).

Total WBC is usually elevated in case of acute appendicitis, and it has been used for a long time as an indicator for acute inflammation. However,

elevated levels can be noted with other conditions, and normal WBC levels can be present with appendicitis (Wang et al., 2007).

Radiological methods such as computed tomography (CT) and ultrasonography, as well as laparoscopy and scoring systems have all been used in the diagnosis of acute appendicitis and each have their benefits and disadvantage (Brinbaum et al, 2000), (Sivit et al, 2001) and (Ajaz et al, 2009).

The concept of clinical score systems can be powerful to guide care of patients, and although these scores are appealing in concept, clinicians should hesitate to apply them until they are validated (Fenyo et al, 1997).

In 1986, Alvarado followed up patients admitted to surgical department at the Nazareth Hospital in Philadelphia with doubted acute appendicitis, until surgery confirmed or disproved diagnosis. He found out eight criteria's had high diagnostic accuracy for acute appendicitis<sup>(2)</sup>. Alvarado scoring system was modified by Kalen et al and named it as Modified Alvarado scoring system (Kalen et al, 1994) and later on many studies were conducted to evaluate the MAS system. (Al-Hashemy et al., 2004), (Sadiq et al., 2002).

150 patients were included in this study clinically diagnosed as acute appendicitis. They were 92 males (61.3%) and 58 females (38.6%). This gender ratio is almost similar to Al-Hahsemy study (Al-Hashemy, 2004).

Their mean age was  $(21.8 \pm 8.4)$ , which is comparable to the most common age of acute appendicitis as published in the literature (Russel et al., 2004).

147 patients had right iliac fossa tenderness (98%), 117 patients had nausea (78%), 99 patients had fever (66%) and 96 patients had anorexia (64%). All patients had WCC done at admission and 126 patients had leucocytosis (84%).

All patients were carefully examined; rebound tenderness was noted in 99 patients (66%). Modified Alvarado score was calculated for each patient.

In this study, we set a cut off value of  $MAS \geq 7$  which is recommended by several studies (Bukhari et al., 2002).

In a study done by Ahmed et al., 2009, 98% of patients with Alvarado score 7 had indication of acute appendicitis on histopathology with positive predictive value (PPV) of 98.1. Horzic et

al., 2009 study reported 100% positive predictive value of score 7 in the diagnosis of acute appendicitis in females. Jan H. et al., 2007 study documented positive predictive value of 85% at score 7. But in another study done by Khan I. et al., 2005 positive predictive value was found to be 83.5% in adults. In our study, the PPV was 87.5% at score  $\geq 7$ , which is comparable to the previous results.

In the current study, at the cut-off point  $MAS \geq 7$ , the sensitivity was 93.33% which is comparable to the results of Sadiq M, 2002 and Saeed, 2004 in their respective studies. Another study conducted by Pruekprasert et al, 2004 reported sensitivity of 7 score of 79%.

The overall specificity of the test at the score 7 was 52.94% (62.5% for males and 44.44% for females) which is comparable to the results of a study conducted by Pouget-Baudry et al., 2010 that showed overall specificity of 58.18%. When a non-inflamed appendix is surgically removed after wrong diagnosis of acute appendicitis, this is called negative appendectomy.

In Ahmed et al, 2009 study, negative appendectomy at score 7 was 13.3% with presence of other pathology for the symptoms, while in 2007 negative appendectomy rate was 11%, while in the current study, negative appendectomy rate was 12.5% at the cutoff value of  $MAS = 7$  which is comparable to the results of the other studies. On the other hand, the overall negative appendectomy rate of all operated patients in the study was 22.07% which clearly proves the importance of using the score in decreasing the undue appendectomies.

The overall accuracy of the MAS in the current study was 84.42% (88.89% for males and 78.13% for females). This is comparable of the results obtained by Owen et al., which was overall diagnostic accuracy of 87.4% (Owen et al., 1992).

When selecting a group of patients with right iliac fossa pain whom it is safe to observe, Owen et al., 1992 found that of 215 patients, none of those with an Alvarado Score less than 6 perforated when observed for 24 hours.

In the present study no patient with MAS of less than 7 had perforation and no patient with a score of less than 4 required surgeries. The same results were also found in Kalan et al., 1994 and other studies which all suggest that it is safe to discharge such patients without prolonged serial

examination or complementary diagnostic studies (Owen et al., 1992), (Malik et al., 1998) & (Winn et al., 2004). Therefore, the Alvarado score should reduce hospitalization since patients with a score 4 can be observed at home (Farahnak et al, 2007).

The patient must recognize the necessity to return for consultation if there is a change in physical symptoms, fever or any other annoying change. The referring physician may also find the score useful to decrease the number of patients inappropriately referred to the emergency room for abdominal pain with a score 4 (Farahnak et al, 2007).

The patients with an intermediate score (4-6) are the typical group for whom operative decision is difficult, especially for adult females (McKay, 2007). Imaging studies (either ultrasound or CT) and diagnostic laparoscopy are useful adjunct to physical and laboratory findings in these patients (Brinbaum et al, 2000) and (Sivit et al, 2001).

On the other hand, in the current study, 4 patients with MAS less than 7 had histopathologically proven appendicitis and this could be missed if totally relied upon the scoring system. So, it should be emphasized that no scoring system is 100% effective, but modifications may increase the accuracy in the future.

The Alvarado score is dynamic and can be recalculated at intervals over 12 to 24 hours of observation as often occurs in patients with an intermediate score (Owen et al., 1992). Such patients have to be observed for up to 24 hours<sup>(1)</sup> and only to order complementary diagnostic studies if suspicion persists. A stable or reduced score is a strong argument against the diagnosis of acute appendicitis. (Andersson et al., 2008), (Lone et al., 2006), (Owen et al., 1992).

The study shows that use of a simple scoring system in patients having acute appendicitis provides a high degree of sensitivity and specificity. It has an easy application since it relies purely on clinical history, examination, and a simple investigation. The reason for its success may be related to the possibility that the clinician is submitted to greater discipline in making the diagnosis. However, Alvarado score is not so good for patient who can't give accurate history as very young or those with communication problems (Khan et al, 2005).

Finally, it has been shown that the score is more effective when all the personnel in the emergency room and on the gastrointestinal surgical service have had a good basis in its use (Ohmann et al, 1999).

## CONCLUSION

The Alvarado score is a reliable, cheap, and reproducible diagnostic method which can be used by both, the primary care and the emergency room physicians, to evaluate a patient who presents with a pain in the right lower abdominal quadrant.

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