

## A Comparative Study between Appendicitis Inflammatory Response Score and Alvarado Score in The Diagnosis of Acute Appendicitis

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### ABSTRACT

**Background:** appendicitis is defined as an inflammation of the inner lining of the vermiform appendix that spreads to its other parts. Despite diagnostic and therapeutic advancement in medicine, appendicitis remains a clinical emergency and is one of the most common causes of acute abdominal pain and one of the most frequent surgical complains in the emergency room.

**Aim of the Work:** the aim of this work was to compare the Appendicitis Inflammatory Response Score to the traditional Alvarado score to determine which is more accurate in the diagnosis of acute appendicitis.

**Patients and Methods:** this descriptive prospective study was carried on 50 patients admitted to the surgical ER of Rashid General Hospital from December 2017 to April 2018 complaining from right lower quadrant pain between the age of 5 years old and 70 years old. All 50 patients had lower quadrant abdominal pain with suspicion of having acute appendicitis, all of them were thoroughly examined and both Alvarado Score and Appendicitis Inflammatory Response Score were applied to all of them, patients with moderate to high probability of having appendicitis (Alvarado Score = 7 or higher, AIR = 8 or higher) underwent open appendectomy and then the resected appendices were sent for histopathology to confirm the diagnosis.

**Results:** the total number of cases with confirmed diagnosis of acute appendicitis by means of post-operative histopathology in our study was 46 out of 50 patients, the AIR score had sensitivity of 95.65% while the Alvarado score had sensitivity of 91.3%.

**Conclusion:** this study demonstrates that the Appendicitis Inflammatory Response Score (AIR) appears to be more accurate than the Alvarado score, easy-to-use and reliable when dealing with a case of right lower quadrant pain with the suspicion of acute appendicitis and can help reduce the negative appendectomy rate.

**Keywords:** Acute Appendicitis, Appendicitis Inflammatory Response Score (AIR), Alvarado Score, C-Reactive protein (CRP).

### INTRODUCTION

Appendicitis is defined as an inflammation of the inner lining of the vermiform appendix that spreads to its other parts<sup>(1)</sup>. Despite diagnostic and therapeutic advancement in medicine, appendicitis remains a clinical emergency and is one of the most common causes of acute abdominal pain and one of the most frequent surgical complains in the emergency room<sup>(2)</sup>.

In 1880, Robert Lawson Tait performed the first appendectomy for appendicitis in England. Now, more than 130 years later, this most common of all surgical diseases can still be a diagnostic problem<sup>(3)</sup>. This is demonstrated by the high negative laparotomy rates documented in the literature. A study performed in 2005 in the Netherlands on 286 cases found that approximately 15% of the patients underwent a negative appendectomy, a number similar to another large Swedish study. The negative appendectomy rate was 13% in another large North American study<sup>(4)</sup>.

It is safe to assume that the negative laparotomy rate declined to approximately 10% with that routine use of ultrasonography (US)<sup>(5)</sup>. The higher sensitivity of computed tomography (CT) seems to have had an even greater effect on the negative laparotomy rate, which has decreased even further to 5-10%. In many European countries, most surgeons still consider acute appendicitis to be a clinical diagnosis and do not routinely perform imaging studies<sup>(6)</sup>.

Scoring systems have been designed to aid in the clinical assessment of patients with acute appendicitis. The Alvarado score is the most well-known and best performing in validation studies, but it has some drawbacks<sup>(7)</sup>.

Its construction was based on a review of patients who had been operated with suspicion of appendicitis, whereas the score is supposed to be used on all patients with suspicion of appendicitis. Furthermore, the score does not incorporate C-reactive protein (CRP) as a variable although many studies have

shown the importance of CRP in the assessment of patients with appendicitis<sup>(8)</sup>.

The recently introduced appendicitis inflammatory response (AIR) score was designed to overcome these drawbacks. This score incorporated the CRP value in its design and was developed and validated on a prospective cohort of patients with suspicion of acute appendicitis.<sup>[9, 10]</sup>

The objective of the present study is to evaluate the Appendicitis Inflammatory Response score on a consecutive cohort of patients with suspicion of acute appendicitis and compare the AIR score's performance to the Alvarado score.

**AIM OF THE WORK**

The aim of this work is to compare the Appendicitis Inflammatory Response Score (AIR) score to the traditional Alvarado score to determine which is more accurate in the diagnosis of acute appendicitis.

**PATIENTS AND METHODS**

This descriptive prospective study was carried on 50 patients admitted to the surgical ER of Rashid General Hospital from December 2017 to April 2018 complaining from right lower quadrant pain between the age of 5 years old and 70 years old. The study was approved by the Ethics Board of Al-Azhar University, written consents were obtained from all patients.

The patients included in this study all had right lower quadrant pain and suspicion of acute appendicitis, all patients were submitted to assessment by history taking; clinical examination; imaging by means of routine ultrasound and selectively CT scans; laboratory investigations including complete blood count, CRP, bleeding profile, liver function tests, kidney function tests, selective pregnancy test for women in child-bearing period and urine analysis; assessment of all patients by both the Alvarado score and Appendicitis Inflammatory Response Score, all patients had Alvarado Score of 7 or higher and Appendicitis Inflammatory Score of 8 or higher. All 50 patients underwent open appendectomy, specimens collected were then sent for histopathology to confirm the diagnosis.

**Statistical methods**

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. The Kolmogorov-Smirnov test was used to verify the normality of distribution Quantitative data were described using range (minimum and maximum), mean, standard deviation and median. Significance of the obtained results was judged at the 5% level. The used tests were:

• **Student t-test**

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

• Receiver operating characteristic curve (ROC)

It is generated by plotting sensitivity (TP) on Y axis versus 1-specificity (FP) on X axis at different cut off values. The area under the ROC curve denotes the diagnostic performance of the test. Area more than 50% gives acceptable performance and area about 100% is the best performance for the test. The ROC curve allows also a comparison of performance between two tests.

**RESULTS**

This study included 50 patients, twenty-six males (52%) and twenty-four females (48%). Twenty-six patients were 20 years of age and older (52%) while twenty-four patients were below the age of 20 years (48%). The minimum age recorded in this study was 9 years old and the maximum age was 59 years old with a median age of (23.50), (Table 1).

**Table 1:** Demographic distribution of the studied cases.

	No.	%
<b>Sex</b>		
Male	26	52.0
Female	24	48.0
<b>Age (years)</b>		
≥ 20	26	52.0
< 20	24	48.0
Mean ± SD.	26.28±1.38	
Median	23.50	

The whole fifty patients (100%) were complaining from right lower quadrant pain.

Forty-one patients (82%) had nausea and vomiting, forty-three patients (86%) had anorexia while only thirty-six patients (72%) were complaining from

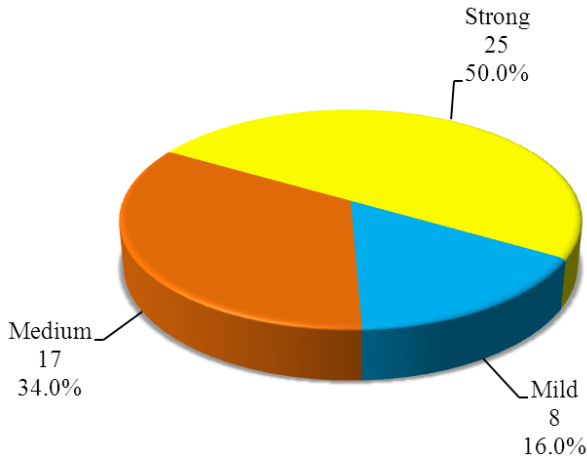
migration of the pain from the periumbilical region to the right lower abdomen, (Table 2).

**Table 2:**Distribution according to symptoms.

Symptoms	No.	%
<b>Nausea&amp; vomiting</b>	41	82.0
<b>Anorexia</b>	43	86.0
<b>RLQ pain</b>	50	100.0
<b>Migratory pain</b>	36	72.0

By palpation, patients gave the characteristic Blumberg sign (rebound tenderness) response in three different degrees of severity, mild, medium and strong.

Eight patients (16%) had mild degree of rebound tenderness while seventeen patients (34%) had medium rebound tenderness and twenty-five patients (50%) had strong rebound tenderness, (Figure 1).



**Figure 1:**Distribution according to the severity of the rebound tenderness.

According to lab results, the temperature degrees of the studied cases were between (37.5°) and (39.4°)with a Mean ± SD. (38.33± 0.46) and median (38.35°), (Table 3).

**Table 3:** Distribution According to temperature.

	Min. – Max.	Mean ± SD.	Median
<b>Temperature (°C)</b>	37.50 – 39.40	38.33± 0.46	38.35

According to the lab parameters, the total leucocytic counts (TLC) of the studied cases were between

(11.80 g/l) and (16.70 g/l) with a Mean ± SD. (14.86±1.27) and a median of (15.05 g/l).

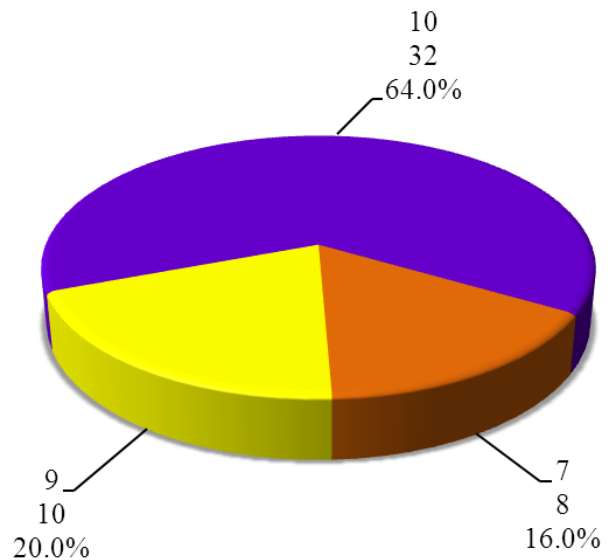
The neutrophils differential percentages of the studied cases were between (66%) and 92% with a Mean ± SD. (82.38 ± 5.22) and a median of (82%). The C-Reactive protein (CRP) of the studied cases were between 9 and 88 with a Mean ± SD. (46.50 ± 17.51) and a median of (49), (Table 4).

**Table 4:** Distribution According to laboratory results.

	Mean ± SD.	Median
<b>TLC</b>	<b>14.86±1.27</b>	<b>15.05</b>
<b>Neutrophils</b>	<b>82.38 ± 5.22</b>	<b>82.0</b>
<b>CRP</b>	<b>46.50 ±7.51</b>	<b>49.0</b>

Eight cases (16%) had a score of (7), ten cases (20%) had a score of (9) and thirty-two cases (64%) had a score of (10) on the Alvarado score.

The minimum Alvarado score recorded in this study was (7) and the maximum score was (10) with a Mean ± SD. (9.32 ± 1.10) and a median of (10.0), (Figure 2).

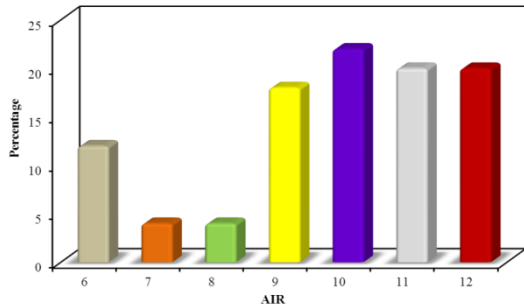


**Figure 2:** Distribution According to the Alvarado Score.

Six cases (12%) had a score of (6) on the AIR score, two cases (4%) had a score of (7), two cases (4%) had a score of (8), nine cases (18%) had a score of (9), eleven cases (22%) had a score of (10), ten cases

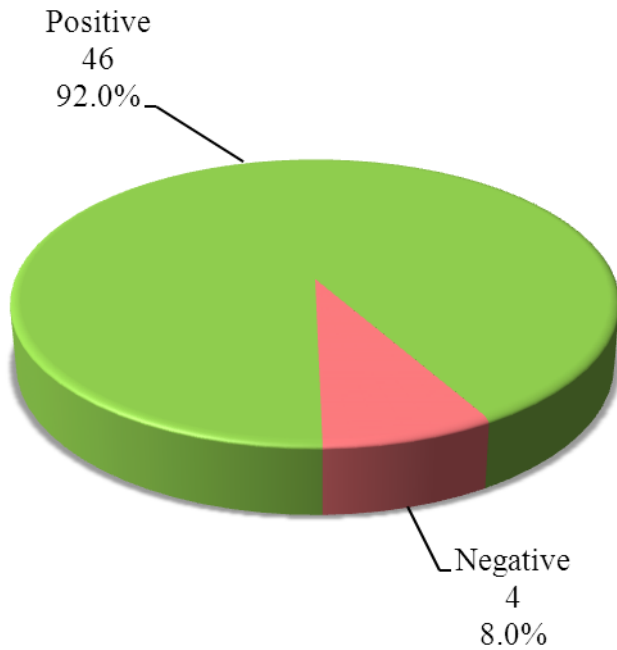
(20%) had a score of (11) and ten cases (20%) had a score of (12).

The minimum AIR score recorded in this study was (6) and the maximum was (12) with a Mean  $\pm$  SD. (9.74 $\pm$ 1.90) and a median of (10.0), (Figure 3).



**Figure 3:** Distribution According to the AIR Score.

Among the studied cases, four cases (8%) had a negative pathology result (no evidence of inflammation of the appendix) and forty-six cases (92%) had a positive pathology result (evidence of inflammation of the appendix), (Figure 4).



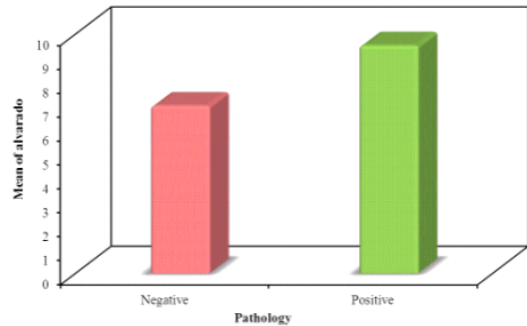
**Figure 4:** Distribution According to pathology result.

According to the Alvarado score: Score of (7) with a Mean  $\pm$  SD. (7.0  $\pm$  0.0) and a median of (7).

The cases with positive pathology had a minimum score of (7) and a maximum score of (10) with a Mean  $\pm$  SD. (9.52  $\pm$  0.89) and a median of (10). The t- value\* was (19.262).

The p- value\* was (<0.001), statistically significant at  $p \leq 0.05$ .

The cases with negative pathology had a minimum score of (7) and a maximum, (Figure 5).



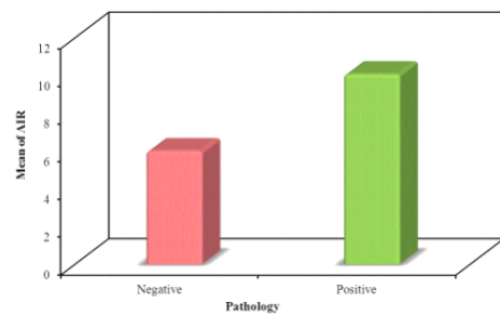
**Figure 5:** Relation between pathology with Alvarado Score.

According to the appendicitis inflammatory response (AIR) score:

The cases with negative pathology had a minimum score of (6) and a maximum score of (6) with a Mean  $\pm$  SD. (6.0  $\pm$  0.0) and a median of (6).

The cases with positive pathology had a minimum score of (6) and a maximum score of (12) with a Mean  $\pm$  SD. (10.07 $\pm$ 1.61) and a median of (10). The t- value\* was (17.114).

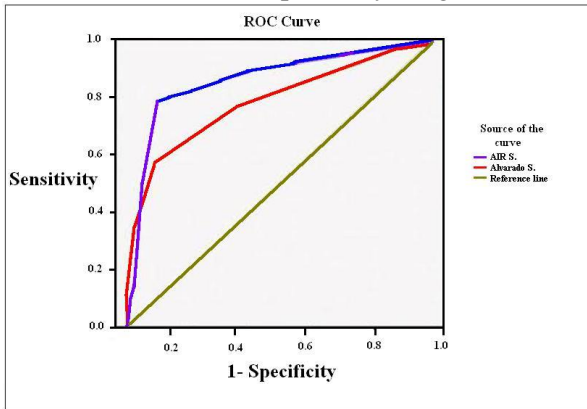
The p- value\* was (<0.001), statistically significant at  $p \leq 0.05$ , (Figure 6).



**Figure 6:** Relation between pathology with AIR Score.

According to the Receiving Operating Characteristic Curve (ROC), the AIR score seems to have a higher sensitivity than the Alvarado score with (95.65%) and (91.3%) respectively. The Air score yielded higher specificity results compared to the Alvarado

score with (69.6%) and (48.36) respectively. This translates to NPV for both AIR and Alvarado scores of (66.7%) and (50%) respectively, (Figure 7).



**Figure 7:** ROC curve for the Alvarado score and AIR score to predict negative appendectomies

## DISCUSSION

Many scoring systems have been designed for diagnosis of acute appendicitis. A clinical scoring system estimates the probability of appendicitis in a patient and should aid in the decision-making process for treatment because of its simple design and application.

In this study, the whole 50 patients were of intermediate-to-high probability of acute appendicitis (Alvarado score 7 and above, Appendicitis inflammatory response score 6 and above), the whole 50 patients were submitted to assessment by both scoring systems and comparisons were made. All patients underwent open appendectomy and the gold standard of this study was assessment by histopathology for the excised appendices.

Among the fifty patients, twenty-six males (52%) and twenty-four females (48%), this shows that men are more susceptible to develop acute appendicitis, even though the differences are not great. This matches well with a previous study by **Genzor Ríos S, et al<sup>(11)</sup>**. in 2016, that showed percentages of (52%) and (48%) for men and women respectively.

In this study, Forty-one patients (82%) had nausea and vomiting, forty-three patients (86%) had anorexia while only thirty-six patients (72%) were complaining from migration of the pain from the periumbilical region to the right lower abdomen. This differs from a study done by **Y. Pouget-Baudry et al.<sup>(12)</sup>**. In 2010, in which, (58%) of patients had nausea and vomiting, (54%) had anorexia with a closer result

for pain shifting of (63%)<sup>[12]</sup>. The differences are probably due to the larger scale of patients in **Pouget-Baudry's et al.<sup>(12)</sup>**. study with 233 patients.

The most common clinical finding in our study was the RLQ tenderness with (100%) of cases followed by Anorexia with (86%) of cases. This correlates well with a previous study done by **Patil S et al<sup>(13)</sup>**. In 2017 where anorexia was the most frequent clinical finding with (99%) of cases followed by the RLQ tenderness with (96%) of cases.

In our study, the PPV for Alvarado score > 6 was (100%) and the NPV was (50%) respectively. In a previous study by **Y. Pouget-Baudry et al.<sup>(12)</sup>**. In 2010, the PPV for the Alvarado score > 6 was (89%) and the NPV was (41.3%) respectively. In our study, the PPV for the AIR score in all cases was (100%) and the NPV was (66.7%). In a previous study by **Kollár D et al.<sup>(14)</sup>**. In 2015 the PPV for the AIR score in all cases was (65%) and the NPV for the AIR score in all cases was (86%).

C-reactive protein demonstrated a sensitivity of (92%) and specificity of (45.5%) in the present study. A recent meta-analysis has shown that there is fivefold increase in the positive likelihood ratio for acute appendicitis when both WBC count and C-reactive protein are elevated<sup>(14)</sup>.

According to the Receiving Operating Characteristic Curve (ROC), the AIR score seems to have a higher sensitivity than the Alvarado score with (95.65%) and (91.3%) respectively. In a study by **Castro et al.** in 2012, the AIR score recorded a higher sensitivity than the Alvarado score with (93%) and (90%) respectively<sup>(15)</sup>.

The Appendicitis Inflammatory Response Score yielded higher specificity results compared to the Alvarado score with (69.6%) and (48.36%) respectively. In a study done by **Patil S et al.** in 2017, the AIR score recorded a higher specificity than the Alvarado score with (63.6%) and (54.5%) respectively<sup>(13)</sup>.

In our study there was no significant difference between the two scores in the prediction of positive appendectomies in the high-risk group (Alvarado 8-10 and AIR 9-12), both scores did well in predicting the positive appendectomies of this group. In addition, the AIR score seems to have outperformed the Alvarado score in the more difficult category of intermediate-risk group (Alvarado 5-7 and AIR 6-8) with higher specificity and sensitivity.

The present study shows that the AIR score has a good statistical discrimination for patients with acute

appendicitis compared to Alvarado score. The discriminatory property of the AIR score remains high in the more difficult to diagnose patients.

### CONCLUSION

This study demonstrates that the Appendicitis Inflammatory Response score (AIR) appears to be more accurate than the Alvarado score, easy-to-use and reliable when dealing with a case of right lower quadrant pain with the suspicion of acute appendicitis and can help reduce the negative appendectomy rate.

### CONFLICTS OF INTEREST

There are no conflicts of interest.

### REFERENCES

1. **Seal A (1981):** Appendicitis: A historical review. *Can J Surg.*, 24:427-33.
2. **Andersson RE, Hugander A, Thulin AJ (1992):** Diagnostic accuracy and perforation rate in appendicitis: Association with age and sex of the patient and with appendectomy rate. *Eur J Surg.*, 158:37-41.
3. **Hale DA, Molloy M, Pearl RH, Schutt DC, Jaques DP(1997):** Appendectomy: A contemporary appraisal. *Ann Surg.*, 225:252-61.
4. **Cuschieri J, Florence M, Flum DR, Jurkovich GJ, Lin P et al. (1981):** Negative appendectomy and imaging accuracy in the Washington state surgical care and outcomes assessment program. *Ann Surg.*, 248:557-63.
5. **Wagner PL, Eachempati SR, Soe K, Pieracci FM, Shou J, Barie PS (2008):** Defining the current negative appendectomy rate: For whom is preoperative computed tomography making an impact? *Surgery*, 144:276-82.
6. **Poortman P, Oostvogel HJ, de Lange-de Klerk ES, Cuesta MA, Hamming JF. (2009):** The use of imaging in the case of suspected acute appendicitis: Opinion of Dutch surgeons. *Ned Tijdschr Geneesk.*, 153:B376.
7. **Alvarado A. (1986):** A practical score for the early diagnosis of acute appendicitis. *Ann Emerg Med.*, 15:557-64.
8. **Owen TD, Williams H, Stiff G, Jenkinson LR, Rees BI. (1992):** Evaluation of the Alvarado score in acute appendicitis. *J R Soc Med.*, 85:87-8.
9. **Douglas CD, Macpherson NE, Davidson PM, Gani JS. (2000):** Randomised controlled trial of ultrasonography in diagnosis of acute appendicitis, incorporating the Alvarado score. *BMJ.*, 321:919-22.
10. **Andersson RE. (2004):** Meta-analysis of the clinical and laboratory diagnosis of appendicitis. *Br J Surg.*, 91:28-37.
11. **Genzor Ríos S, Rodríguez Artigas, et al.(2016):**Ultrasonography and the Alvarado score in the diagnosis of acute appendicitis: impact on the negative appendectomy rate. *Emergencias.*, 28:396-399
12. **Pouget-Baudry, Y & Mucci, S & Eyssartier, E et al., (2010):** The usefulness of the Alvarado Score in the management of right lower quadrant abdominal pain in the adult. *Journal of visceral surgery.* [www.sciencedirect.com/science/article/pii/S187878861000329?via%3Dihub#](http://www.sciencedirect.com/science/article/pii/S187878861000329?via%3Dihub#)
13. **Patil S, Harwal R, Harwal S, Kamthane S.(2017):** Appendicitis8 inflammatory response score: a novel scoring system for acute appendicitis. *Int Surg J.*, 4:1065-70.
14. **Kollár D, McCartan DP, Bourke M, Cross KS, Dowdall J.(2015):** Predicting acute appendicitis? A comparison of the Alvarado score, the Appendicitis Inflammatory Response Score and clinical assessment. *World J Surg.*, 39(1) 104-109.
15. **De Castro SMM, Ünlü C, Steller EPH, Wagenveld BA, Vrouwenraets BC. (2012):** Evaluation of the appendicitis inflammatory response score for patients with acute appendicitis. *World J Surg.*, 36(7):1540-5.