Original Article

Diagnostic Accuracy of Alvarado and Appendicitis Inflammatory Response Score in the Diagnosis of Acute Appendicitis

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ABSTRACT

Objective: To evaluate diagnostic accuracy of Alvarado score (AS) and Appendicitis Inflammatory Response (AIR) score in the diagnosis of acute appendicitis (AA) in our setup undergoing emergency appendectomy, keeping histopathological findings as gold standard.

Study Design: Cross sectional study.

Place and Duration of Study: This study was conducted at the surgical department DHQ Teaching Hospital and Sarhad Surgical Hospital, Kohat, Pakistan from January 1, 2022, to June 30, 2022.

Materials and Methods: Total of 204 consecutive suspected cases of AA were included in the study. Alvarado and AIR scores were prospectively calculated and postoperative histopathological confirmation report was obtained for each case. The validity of scoring systems was assessed in terms of sensitivity, specificity, positive predictive value, diagnostic accuracy and area under the receiver operating curve (AUC).

Results: The study comprised of 204 patients having mean age of 27.08±11.30 years with 111 (54.41%) males and 93 (45.59%) females. Confirmed cases of AA were seen in 114/119 and 55/85 patients at AS >7 and <7. AIR score >8 and <8 revealed confirmation of AA in 130/134 and 57/68 patients respectively. AS showed sensitivity, specificity, positive predictive value of 64.70%, 88.23%, 96.49% and accuracy of 68.62% while for AIR it was 70.58, 94.11%, 98.36% and 74.50% respectively. Furthermore, AUC for AIR score was found to be better (0.70) than Alvarado score (0.64).

Conclusion: Alvarado and AIR scores have fair diagnostic accuracy of approximately 72%. Application of Alvarado and AIR scores for the diagnosis of AA can decrease avoidable radiological and surgical interventions.

Key Words: Acute appendicitis; Alvarado score; AIR score; Histopathology; Appendectomy; Diagnostic accuracy

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INTRODUCTION

Acute appendicitis (AA) is one of the commonest abdominal surgical emergencies over all age groups with a lifetime risk of 7-8%.(1) It affects 7%-10% of the world population.(2) It is more frequent in Asian countries including Pakistan with estimated incidence of 21%.(3)

Despite so much frequent occurrence and the technological advancements in diagnostic techniques, the diagnosis of AA still remains uncertain in many cases especially in young women and children leading to undue delay in diagnosis resulting in complications. Although AA is mainly a clinical diagnosis depending upon careful clinical history and physical examination but many clinical conditions mimic AA as well as AA has atypical presentation in 50% of the cases.(4) So a quick and timely diagnosis is necessary in making decision of management plan and to prevent unnecessary negative appendectomies resulting in higher finances and morbidity and mortality. Hence, it is beyond question that a quick and easy modality is inevitable to diagnose AA in a resource limited clinical settings which can be of great help to practising surgeons.

Various scoring systems have evolved over time to assist the clinical diagnosis of AA in suspected cases but only a few have proven acceptable. The diagnostic accuracy of AA has enhanced only slightly in the last few years. The characteristic triad of a history, clinical examination and leucocytosis has a diagnostic accuracy rate < 80%, and whilst radiological modalities like Abdominal scan and computed tomography if included, accuracy does not even reach 90%. but CT scan has

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some drawbacks and ultrasound is operator dependent. The Alvarado scoring (AS) system ie famous and frequently used due to its easy applicability and very good sensitivity and specificity.[2] But AS misses many cases – depending on the severity score and over predicting some cases particularly in women.[5] The Appendicitis Inflammatory Response (AIR) scoring reported in 2008 has been regarded as a better diagnostic tool by many researchers particularly in the West [2, 5, 6] as it has better specificity and positive predictive value than AS because it incorporates C-Reactive Protein, a well-proven important biomarker, as a variable in addition to taking into consideration objective patient's symptoms.

Alvarado score is commonly used in Pakistan and more statistics are available on it while AIR score is less commonly used clinically; so there is a need to measure the diagnostic accuracy of both diagnostic tools simultaneously in same patients to determine the better scoring modality in our settings having completely different ethnic background and diet. Furthermore, differences have been observed in accuracy when the mentioned scores are applied to varied populations.

MATERIALS AND METHODS

This cross sectional study was conducted at Surgery Department, DHQ Teaching Hospital KDA Kohat and Sarhad surgical Hospital, a private surgical Hospital at Kohat, Pakistan from January 1, 2022, to June 30, 2022. The study was priorly approved from the ethical board and research committee of the hospital and informed consent for participation in the study was obtained priorly. Sample size calculation was done using standardized formula for sample size assessment for diagnostic test studies.[7] Total of 204 patients of any age and either gender presenting with sudden-onset and non-traumatic right lower quadrant abdominal pain, suspected to be having AA (inflammation of appendix of less than 4 days duration) were collected by consecutive sampling technique. All those cases with appendicular lump, pregnant ladies, patients with previous abdominal surgery or known cases of abdominal malignancy and patients who showed unwillingness for surgical intervention were excluded from the study.

Detailed physical examination was done and laboratory investigations including blood complete count, urine routine examination and C-reactive protein was carried out in all admitted patients. Abdominopelvic ultrasonography was conducted in some selected cases especially in females to rule out differential diagnosis. Alvarado score (AS) of 7 and AIR score of 8 were taken as high probability for acute appendicitis as per available literature.[8, 9] Preoperatively, Alvarado and AIR score of each patient was recorded. AS of >7 and AIR score of >8 was indicative of acute appendicitis but AS <7 and AIR score <8 meant normal appendix but the decision for surgical intervention was only based upon clinical suspicion. All the cases underwent open emergency appendectomy under general anaesthesia after taking informed consent. Intra-operative findings were noted and routine post-operative care was given to all the patients. Uncomplicated appendicitis means all those patients having no evidence of perforation or abscess formation, and in which the inflammation is typically limited to the appendix while complicated appendicitis includes all those cases having perforation of the appendix, abscess formation or empyema. Normal appendix intraoperatively means appendix which looks normal with naked eye appearance on operation. Each resected specimen of appendix was referred to department of Pathology for histopathology. Acute appendicitis was established histopathologically when there was exudation in all the layers of appendix with infiltration of neutrophils granulocytes into the muscularis propria layer. Alvarado and AIR scores were correlated with resected appendicular histopathological findings. The outcome was classified as true positive (TP), true negative (TN), false positive (FP), false negative (FN) and the paired measures of diagnostic accuracy i.e., the sensitivity (Sen), specificity (Spe), positive predictive value (PPV), negative predictive value (NPV), diagnostic accuracy (DA) rate and AUR were calculated. The area under the receiver operating characteristic (ROC) curves was used to examine the performance characteristics of the scoring systems individually.

Data was prospectively collected on a well-structured proforma and statistical analysis was conducted through SPSS version 25. Frequency and percentage were computed for qualitative variables like gender. Mean±SD was used for quantitative variables like age. The data were labelled through the histopathologically confirmed diagnosis and paired measures for the Alvarado and AIR scores were calculated as per standard formulae for sensitivity, specificity, positive predictive value and negative predictive value. The two by two table designs were drawn to determine diagnostic accuracy.

RESULTS

Out of 204 patients, 111(54.41%) were males and 93 (45.59%) females with female to male ratio of 1:1.19. The most common (50.98%) observed affected age group was 21-40 years. The age and sex distribution of the patients has been depicted in Table I. There were 114 patients having AS of >7 while 90 patients had score of <7 while 122 patients showed AIR score of >8 and 82 patients were observed to have score <8.

The AIR score ranged from 6-11 with mean of 8.82±2.93 and AS ranged from 5 to 9 with a mean of 7.53±2.52 respectively. Out of 204 patients, 191 (93.62%) cases were diagnosed intraoperatively and

acute appendicitis was confirmed histopathologically in 110 (96.49%) and 120 (98.36%) patients at Alvarado >7 and AIR >8 scores respectively. Table-2 & 3 represent the values of test and disease positive cases with sensitivity, specificity, positive predictive value, negative predictive value and accuracy of Alvarado and AIR scores for both the risk groups. Overall the diagnostic accuracy of AS and AIR scoring systems in diagnosis of acute appendicitis was found to be 71.56% at the maximum cutoff values. The commest intraoperative finding was of uncomplicated appendicitis 147 (72.05%) and overall negative appendectomy rate (NAR) was found to be 5.13%. The predictive validity of AS as assessed by area under the ROC curve was 0.64 as compared to 0.70 for AIR score with cutoff values of 7 and 8 respectively (Figure 1).

Table No.1: Age and sex distribution with type of appendicitis, observed in suspected cases of acute appendicitis (n=204)

Age group (years)	Total (n=204)		Males (n=111)		Females(n=93)		Type of appendicitis		
	Frequency	%age	Frequency	%age	Frequency	%age	Uncomplicated	Complicated	Normal
<20	84	41.17	46	41.44	38	40.86	65	15	4
2 -40	104	50.98	56	50.45	48	51.61	74	22	8
41-60	12	5.88	6	5.40	5	5.37	6	5	1
>61	4	1.96	3	2.70	2	2.15	2	2	0

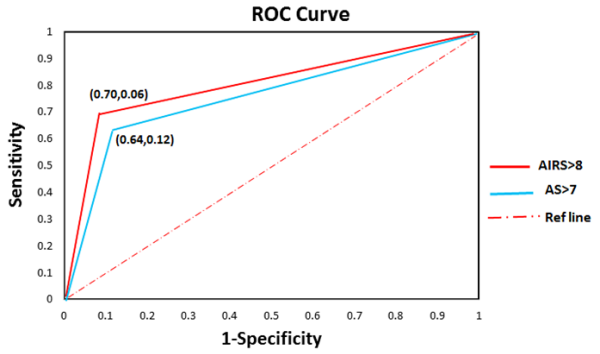

Figure No.1: ROC of the AIR & Alvarado scores at their maximum cutoff values in the study population

Table No.2: Risk score of Alvarado and histopathology findings in study population when cutoff is 7 (n=204)

	Histo-pathology +	Histo-pathology -	
AS>7	110 (TP)	4 (FP)	114
AS<7	60 (FN)	30 (TN)	90
	170	34	204

AS >7=Sen: 64.70%, Spe: 88.23%, PPV: 96.49%, NPV: 33.33%, DA: 68.62%, NAR: 3.50%

Table No.3: Risk score of AIR and histopathology findings in study population when cutoff value is 8 (n=204)

	Histopathology +	Histopathology -	
AIR>8	120 (TP)	2 (FP)	122
AIR<8	50 (FN)	32 (TN)	82
	170	34	204

AIR>8=Sen: 70.58%, Spe: 94.11%, PPV: 98.36%, NPV: 39.02, DA: 74.50%, NAR: 1.63%

DISCUSSION

The analysis of current study revealed better sensitivity and specificity of AIR score (70.58% & 94.11%) as compared to AS (64.70% and 88.23%) at high risk levels. Similarly, positive predictive values of AIR scores (98.36%) was observed as compared to AS (96.49%) at risk category. AIR and Alvarado scoring systems performed better at high-risk levels showing accuracy of 74.50% and 68.62% respectively. The negative appendectomy rate for AS and AR were found to be 1.63% and 3.50% respectively while AUC for AIR score was found to be better (0.70) than Alvarado score (0.64) at high probability levels. On the other hand low-medium risk categories of both Alvarado and AIR scoring systems (25.49% Vs. 31.37%) were quite unhelpful in estimating diagnosis of AA.

In our study out of 114 (55.88%) cases having Alvarado score of >7, 110 patients showed histopatological evidence of AA with PPV of 96.49% and specificity of 88.23% which is comparable to study conducted by other researchers across the globe.[9-11] Contrarily, some studies have reported lower PPV from 79-90% and specificity of 75-83%..[12, 13] Alvarado[14] recommended that patients with an AS of >7 should directly undergo surgery without any more workup. As far as AIR score of >8 is concerned out of 122 patients, 120 showed histopatological evidence of AA with PPV of 98.36% and specificity of of 94.11% which is in consistent with studies conducted by other researchers worldwide.[4, 8, 11] NAR at Alvarado score >7 was observed to be 3.50% means 4 patients with >7 score had non-inflamed appendix which is in accordance with study conducted by other investigators.[9, 15] On the other hand some rearchers have shown higher NAR ranging from 11-20% at Alvarado score >7.[12, 13] Similarly NAR at AIR score >8 was observed to be 1.63% means two patients showed normal appendix hispathlogically which is in accordance with study conducted by Karki OB and Hazara NA.[4] Conversely our study cohort showed evidence of AA on histopathology in 60.97% and 66.66% cases with negative appendectomy in 30/90 and 32/ 82 patients at Alvarado score <7 and AIR score <8 respectively. Very low NAR observed in low-medium score groups in our study may be due to the fact that

many patients are referred from gyne department and primary health-care hospitals after taking initial treatment. Furthermore, such cases of low-medium probability group actually had AS score >5 and AIR score >6, which then proceeded for surgical intervention just on clinical suspicion. Increased number of histopathological diagnosis of acute appendicitis in these low risk groups reported in our series is comparable with that of Karki OB, Hazra NK.[4] Our study showed 66.66% evidence of AA on histopathology with NAR of 33.33% which may be due to the fact that this study was conducted in teaching hospital where cases were mostly referred from periphery after taking unwise use of antibiotics which may change the disease process and course.

The AIR score showed good performance than Alvarado Score because C-Reactive Protein shows a greater discriminative power as has been supported by 10 out of 11 comparative studies.[16, 17] Although some studies have recommended combined use of both the scoring systems to increase the diagnostic accuracy and good decision making to decrease negative appendectomies in suspected cases of AA.[2] Overall accuracy of both the scoring systems was found to be approximately 72% in our study which is comparable with studies conducted elsewhere.[4, 18]

The current study showed that the predictive validity of AS as measured by area under the ROC curve was 0.64 as compared to 0.70 for high probability scores showing a good statistical correlation between two scores. Karki OB and Hazra NK[4] in a study conducted on 217 Nepalese patients reported AUR for AS 0.58 and 0.70 for AIR respectively for high cutoff values while Pogorelic et al[19] found AUR of 0.74 for Alvarado score and Anderson et al[8] reported 0.83 for AIR at maximum cutoff values (>7 for AS and >8 for AIR).

The limitations of our study include relatively small sample size of the study population from a single centre and cross sectional nature of the study which could diminish the significance of the associations.. Further, multi-centric, prospective studies with larger sample size are recommended for precised and generalizable conclusions regarding diagnostic accuracy of AIR and Alvarido Score of acute appendicitis.

CONCLUSION

Alvarado and AIR scoring systems are useful tools as those are easy and simple to use in resource-limited settings. AIR showed relatively better specificity, positive predictive value and AUR than Alvarado scoring system. Furthermore, Alvarado and AIR scores revealed fair diagnostic accuracy of approximately 72%. Application of Alvarado and AIR scores for the diagnosis of AA can decrease avoidable radiological and surgical interventions.

Author's Contribution:

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Conflict of Interest: The study has no conflict of interest to declare by any author.

REFERENCES

1. Chen CY, Chen YC, Pu HN, Tsai CH, Chen WT, Lin CH. Bacteriology of acute appendicitis and its implication for the use of prophylactic antibiotics. Surgical Infections 2012;13(6):383-90.
2. Karami MY, Niakan H, Zadebagheri N, Mardani P, Shayan Z, Deilami I. Which one is better? Comparison of the acute inflammatory response, Raja Isteri Pengiran Anak Saleha Appendicitis and Alvarado scoring systems. Annals Coloproctol 2017;33(6):227.
3. Gerst PH, Mukherjee A, Kumar A, Albu E. Acute appendicitis in minority communities: an epidemiologic study. J National Med Assoc 1997; 89(3):168.
4. Karki O, Hazra N. Evaluation of the appendicitis inflammatory response score against Alvarado score in diagnosis of acute appendicitis. Kathmandu University Med J 2020;18(2):68-72.
5. Kollár D, McCartan D, Bourke M, Cross K, Dowdall J. Predicting acute appendicitis? A comparison of the Alvarado score, the Appendicitis Inflammatory Response Score and clinical assessment. World J Surg 2015;39(1):104-9.
6. Andersson M, Kolodziej B, Andersson R, Andersson M, Eriksson T, Ramsing A, et al. Randomized clinical trial of Appendicitis Inflammatory Response score-based management of patients with suspected appendicitis. J Br Surg 2017;104(11):1451-61.
7. De Castro S, Ünlü C, Steller EP, Van Wagensveld B, Vrouenraets B. Evaluation of the appendicitis inflammatory response score for patients with acute appendicitis. World J Surg 2012;36(7): 1540-5.
8. Andersson M, Kolodziej B, Andersson RE. Validation of the appendicitis inflammatory response (air) score. World J Surg 2021;45(7): 2081-91.
9. Memon AA, Vohra LM, Khaliq T, Lehri A. Diagnostic accuracy of Alvarado score in the

diagnosis of acute appendicitis. Pak J Med Sci 2009;25(1):118-21.
10. Paravengal HM, Binub K. Study on the diagnostic accuracy of the Alvarado score in the diagnosis of acute appendicitis. Int J Surg 2020;4(4):275-7.
11. Jose T, Rajesh P. Appendicitis Inflammatory Response Score in Comparison to Alvarado Score in Acute Appendicitis. Surg J 2021;7(03): e127-e31.
12. Al Awayshih MM, Nofal MN, Yousef AJ. Evaluation of Alvarado score in diagnosing acute appendicitis. Pan Afr Med J 2019;34.
13. Özsoy Z, Yenidoğan E. Evaluation of the Alvarado scoring system in the management of acute appendicitis. Turkish J Surg 2017;33(3):200.
14. Alvarado A. A practical score for the early diagnosis of acute appendicitis. Annals Emerg Med 1986;15(5):557-64.
15. Jo YH, Kim K, Rhee JE, Kim TY, Lee JH, Kang SB, et al. The accuracy of emergency medicine and surgical residents in the diagnosis of acute appendicitis. Am J Emerg Med 2010;28(7):766-70.
16. Bhangu A, Nepogodiev D, Matthews J, Morley G, Naumann D, Ball A. RIFT Study Group on behalf of the West Midlands Research Collaborative. Evaluation of appendicitis risk prediction models in adults with suspected appendicitis. Br J Surg 2020;107(1):73-86.
17. Yeşiltaş M, Karakaş DÖ, Gökçek B, Hot S, Eğin S. Can Alvarado and Appendicitis Inflammatory Response scores evaluate the severity of acute appendicitis? Turkish J Trauma and Emerg Surg 2018;24(6):557-62.
18. Ak R, Doğanay F, Unal Akoğlu E, Akoğlu H, Uçar AB, Kurt E, et al. Predictive value of scoring systems for the diagnosis of acute appendicitis in emergency department patients: Is there an accurate one? Hong Kong J Emerg Med 2020; 27(5):262-9.
19. Pogorelic Z, Rak S, Mrklic I, Juric I. Prospective validation of Alvarado score and Pediatric Appendicitis Score for the diagnosis of acute appendicitis in children. Pediatr Emerg Care 2015;31(3):164-8.