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ORIGINAL ARTICLE

Assessing diagnostic precision of the modified Alvarado score using histopathology as benchmark.

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ABSTRACT… Objective: To assess modified Alvarado scores accuracy in diagnosing acute appendicitis. **Study Design:** Cross-sectional Project. **Setting:** Ayub Teaching Hospital, Abbottabad. **Period:** 1st June 2022 to 11th December 2022. **Methods:** A total of 185 patients aged 12–90 yrs. with suspected AA who underwent emergency appendectomy were studied. MAS was calculated at admission, and diagnosis was confirmed via histopathological analysis of appendectomy specimen. Diagnostic accuracy was inferred by commuting sensitivity, specificity, PPV, and NPV, with stratification by age and gender. **Results:** MAS diagnosed 54.6% of cases as AA-positive. Histopathology confirmed AA in 80.5% of patients. MAS correctly identified 62.7% of cases. Inferential analysis revealed 50.3% sensitivity, 15.1% specificity, 62.4% PPV, and 33.3% NPV. Sensitivity was higher in males (89.2%) and in the 26–35 age group (75.6%). **Conclusion:** MAS is an easily applicable practical tool to diagnose AA: especially at score extremes. However, moderate sensitivity and low specificity highlight the continued importance of clinical acumen. A cut-off score >5 may improve diagnostic accuracy in this population, and region-specific thresholds should be considered.

Key words: Appendicitis, Diagnosis, Scoring Systems, Sensitivity, Specificity.

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INTRODUCTION

Acute appendicitis is an emergent surgical condition hence it requires quick diagnosis to reduce the chances of morbidity and further serious complications.[1] Appendectomy ranks as the most common emergency abdominal procedure, with AA diagnosis primarily based on clinical judgment. However, relying solely on clinical suspicion may result in unnecessary removal of a healthy appendix in approximately 15% of cases.[2,3] The typical form of acute appendicitis is diagnosed and treated easily. Sometimes atypical features are present which make the diagnosis difficult. Hence there is a need for a clinical scoring system for diagnosis of acute appendicitis to avoid negative appendectomies.[4] Hence, a number of scoring systems have been developed all over the globe ranging from some very sophisticated ones to the simple modified Alvarado score (MAS).[5] Kalan and colleagues introduced a revised version of the Alvarado scoring system, excluding the left shift in leukocytes, thereby adjusting the total score range to 0–9.[6] in terms of clinical presentation the typical central abdominal pain that shifts to the right lower quadrant is not very common and the inflammatory markers including raised CRP and leukocytosis aren't very specific.[7,8] An abdominal CT-scan has the ability to recognize acute appendicitis with high accuracy, but the high dose radiations are harmful.[9]

Khan S and co-authors concluded that Modified Alvarado scoring system was found to be 62% specific, 83% sensitive and 65% accurate. Where further analysis showed that PPV was 94% and NPV was 33%.[10] A study conducted by Man et al. inferred that MAS had 80.7% sensitivity and 100% specificity for acute appendicitis.[11] The appendicitis prevalence is variable all around the globe and accurate recognition of the condition is still a challenge. Where delay in diagnosis and management can cause significant morbidity and occasional mortality. Hence role of MAS in clinical diagnosis of acute appendicitis should be assessed in every region and region specific inferences should be utilized to help improve provision of early and effective care that will un-doubtfully lower

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economic burden on patients as well as healthcare. Hence with this study the aim was assessment of Modified Alvarado Score's accuracy in diagnosing acute appendicitis.

METHODS

This cross-sectional study was conducted in the Surgical Unit of Ayub Teaching Hospital, Abbottabad after approval from medical ethics committee (1/6/22). The study duration spanned from 1st June 2022 to 11th December 2022. A total of 185 patients were included. Non-probability consecutive sampling was employed for collection of the sample population. All patients aged from 12 to 90 years, presenting with suspected acute appendicitis and undergoing emergency appendectomy, regardless of gender were included. Those that didn't consent for inclusion in the study or those having any other febrile illness or any history of small or large intestine disease were excluded.

Patients who arrived at the General Surgery Department with abdominal pain and met the inclusion criteria for appendectomy were recruited following ethical clearance from the institutional review board. Each participant or their legal guardian provided informed consent after receiving a briefing on the study design, research objectives, and potential risks and benefits. The Modified Alvarado Score (MAS) was calculated at the time of admission, and acute appendicitis was labeled according to the operational definition. All patients underwent appendectomy, and the surgical specimens were sent to pathology department for histopathological analysis to confirm the diagnosis. Patient data including age, gender, duration of symptoms, and place of residence were recorded using a pre-designed proforma. The authors of this study themselves collected the data.

Acute appendicitis was suspected in cases with typical migratory abdominal pain associated with nausea, vomiting, anorexia , right iliac fossa tenderness and rebound tenderness, fever of 37.3°C or higher, and TLC count >10,000. Histopathological features that were considered to make diagnosis of acute appendicitis included microscopic evidence of acute inflammation, luminal obstruction due to faecolith, lymphoid hyperplasia, fibrosis, parasites, and endometrial tissue might be seen on the histopathological report. The Modified Alvarado Score serves as a clinical score for evaluating suspected cases of acute appendicitis. The score includes six clinical items and one laboratory measurement, totaling nine points. The point distribution is as follows: abdominal pain that migrates to the right-iliac region = 1, anorexia = 1, nausea / vomiting = 1, tender right-iliac fossa = 2, rebound tenderness at the aforementioned site = 1, body temperature of 37.3°C or more = 1, leukocytosis >10,000 = 2.

Diagnostic accuracy of MAS was determined in terms of sensitivity, specificity, positive predictive value and negative predictive value in comparison to histopathological assessment of acutely inflamed appendix. Where sensitivity measures the proportion of actual appendicitis cases correctly identified, computed as: True Positives ÷ (True Positives + False Negatives) × 100. Specificity is ability of the Alvarado score to correctly identify those patients who do not have acute appendicitis out of the total patients without suspected acute appendicitis, and is calculated as: True negatives / (True negatives + False positives) × 100. Positive Predictive Value is the percentage with a positive results who actually have the pathology, calculated as: True positives / (True positives + False positives) × 100. Negative Predictive Value is the percentage of patients with a negative Alvarado score who are disease free, calculated as: True negatives / (True negatives + False negatives) × 100.

Here, True Positive are patients with positive histopathology and positive Alvarado score. True Negative are the ones with negative histopathology and Alvarado score. False Positive are patients with positive Alvarado score and negative histopathology. False Negative are the ones with negative score and positive histopathology for acute appendicitis.

Data Analysis

SPSS version 23.0 was utilized. Categorical variables including gender and place of residence were reported as frequencies and proportions, while quantitative variables like age and symptoms duration were reported as means and standard deviations. A 2×2 contingency table was

constructed to calculate measures of diagnostic accuracy. Sensitivity, specificity and respective predictive values were computed using standard formulas. These measures were further stratified by age, gender, place of residence, and duration of symptoms.

RESULTS

A sum of 185 cases were studied. Majority were middle aged males. As per the age distribution majority were aged 26–35 years (45; 24.3%), followed by 36–45 years (44; 23.8%), 46–55 years (40; 21.6%), 56–65 years (33; 17.8%), and 15–25 years (23; 12.4%). Males constituted 102 (55.1%) of the sample, whereas females accounted for 83 (44.9%). Among the studied cases, Modified Alvarado scoring diagnosed 101 cases (54.6%) as positive and 84 (45.4%) cases as negative for acute appendicitis. Histopathological analysis was done to compare the results of tissue analysis with MAS score. Histological examination validated the presence of acute appendicitis in 149 individuals (80.5%), while 36 cases (19.5%) showed no pathological evidence of the condition. MAS essentially achieved an accurate diagnosis in 116 cases (62.7%), whereas inaccurately classified 69 (37.3%). These are presented in Table-I.

TABLE-I

2 by 2 contingency table format

		Histopathological results	
		Positive	**Negative**
Alvarado score results	Positive	a	b
	Negative	c	d

Contingency analysis summarized in Table-II revealed 93 true positives (Alvarado positive + histopathology positive), 8 false positives, 56 false negatives, and 28 true negatives. Based on these findings, the sensitivity was 50.3%, specificity was 15.1%, false-negative-rate was 22.2%, false-positive-rate was 30.3%, positive-predictive-value (PPV) was 62.4%, negative-predictive-value (NPV) was 33.3%, and prevalence was 54.6%.

Analysis by gender revealed greater sensitivity among male participants (91 out of 102; 89.2%) compared to females (25 out of 83; 30.1%). Age-wise sensitivity was highest in the young middle age group i-e 26–35 age group (34/45; 75.6%), followed by 15–25 years (65.2%), 56–65 years (63.6%), 46–55 years (55.0%), and lowest in 36–45 years (54.5%). (Table-III)

TABLE-II

Descriptive statistics of the studied population. (n=185)

Variable	Category	Frequency	Percent (%)
Age Group	15–25 Years	23	12.4
	26–35 Years	45	24.3
	36–45 Years	44	23.8
	46–55 Years	40	21.6
	56–65 Years	33	17.8
Gender	Male	102	55.1
	Female	83	44.9
Modified Alvarado Score	Positive	101	54.6
	Negative	84	45.4
Histo-pathology	Positive	149	80.5
	Negative	36	19.5
Diagnostic Accuracy	Yes	116	62.7
	No	69	37.3

TABLE-III

2 by 2 contingency table showing diagnostic performance of modified Alvarado in comparison to histopathological analysis as gold standard; with diagnostic parameters mentioned below. (n=18)

	Histopathology Positive	Histopathology Negative	Total
Alvarado Positive	93 (True-Positive)	8 (False-Positive)	101
Alvarado Negative	56 (False-Negative)	28 (True-Negative)	84
Total	149	36	185

Diagnostic Performance Metrics

- Sensitivity: 50.3%
- Specificity: 15.1%
- False Negative Rate: 22.2%
- False Positive Rate: 30.3%
- Positive Predictive Value (PPV): 62.4%
- Negative Predictive Value (NPV): 33.3%
- Prevalence of Acute Appendicitis: 54.6%

TABLE-IV

Age and gender stratification of MAS's accuracy in diagnosing acute appendicitis (n=185)

Group	Sub-group	True Positives	False Negatives	Total	Sensitivity
Gender	Male	91	11	102	89.2%
	Female	25	58	83	30.1%
Age Group	15–25 Years	15	8	23	65.2%
	26–35 Years	34	11	45	75.6%
	36–45 Years	24	20	44	54.5%
	46–55 Years	22	18	40	55.0%
	56–65 Years	21	12	33	63.6%

DISCUSSION

The Alvarado score offers a straightforward, non-invasive method for diagnosing appendicitis. It is dependable, cost-effective, and suitable for use in emergency settings without the need for advanced diagnostic equipment. There was no statistically significant difference in the diagnostic accuracy of acute appendicitis between emergency medicine residents and general surgery residents when utilizing the Alvarado score.[10]

Although multiple studies have validated the Alvarado score, some authors have advocated for modifying the diagnostic threshold to 4 or 6 to enhance accuracy.[7,8] In the present study, 98% of patients with an Alvarado score >7 demonstrated histopathological evidence of acute appendicitis, yielding a positive predictive value (PPV) of 98.1% and a sensitivity of 58%, which is comparable to the findings of Man et al., who ha/s reported a sensitivity of 53.8%.[12] These results suggest that a high Alvarado score may serve as a useful tool in guiding the decision for immediate appendectomy, particularly among junior surgeons. Melek et al. reported a PPV of 100% for scores >7 in female patients[13], while Gupta et al. documented a PPV of 85% at the same threshold.[14] In contrast, Khalil et al. found a PPV of 83.5% in adult populations.[15] Pruekprasert et al. observed a sensitivity of 79% for scores >7, whereas sensitivity based solely on clinical judgment was 96%. In our study, the clinical experience alone was able to yielde a sensitivity of 91%, regardless of the Alvarado score.[16]

The negative-appendectomy rate in our cohort for scores >7 was only 1.8%, with a single patient undergoing surgery for a non-inflamed appendix. This closely aligns with Melek et al., who reported zero false positives at this threshold.[13] Conversely, Khalil et al. noted a negative appendectomy rate of 15.6%[15], and Sangoli et al. reported a rate of 11%.[17] The notably smaller rate in our study may be attributed to the fact that many cases were referred from primary care centers after 1–2 days of symptom onset, often with a high clinical suspicion of appendicitis.

The single case in our study with a normal appendix despite a score more than 7 was a female. Literature supports the need for additional diagnostic modalities in female patients to reduce false positives. Nunna et al. demonstrated that combining the Alvarado score with selective laparoscopy in adult females improved diagnostic accuracy and eliminated negative appendectomies at scores >7.[18] However, Memon et al. in his studyreported a PPV of 80% at scores >7 in females, with a high negative appendectomy rate and a sensitivity of 61%.[19]

In our population, patients with scores <7 who underwent surgery based solely on clinical judgment showed histopathological confirmation of appendicitis in 82% of cases, with a negative-appendectomy rate that of 17%. Majority of these had scores >5, whereas all patients with scores of 3 or 4 had a non-inflamed appendix. Memon et al. reported a PPV of 66.6% for scores <7[19], while Melek et al. documented a negative appendectomy rate of 5% at scores >4, with a PPV of 94%.[13] The higher rate of histopathologically confirmed appendicitis in our <7 score group may reflect the referral pattern to Pakistan Institute of Medical Sciences, a tertiary level hospital. It is a common practice in our setting for patients to receive empirical antibiotic therapy as self-prescription or by quacks, which may alter the disease course and clinical presentation, resulting in lower Alvarado scores.

There was no statistical difference between emergency medicine resident using the Alvarado

score and general surgery resident in terms of suspecting the diagnosis of acute appendicitis when using Alvarado score.[10]

While numerous investigations have supported the validity of the Alvarado score, others suggest adjusting the diagnostic threshold to 4 or 6 for improved accuracy.[7,8] In this study, 98% of patients with Alvarado score >7 have evidence of acute appendicitis on histopathology with positive predictive value of 98.1% and sensitivity of 58% which is comparable to study conducted by Man et al giving sensitivity of 53.8%.[12] This shows that need of immediate surgical can be determined by caretakers on calculation of a high Alvarado score. Melek et al study documented 100% positive predictive value of score >7 in the diagnosis of acute appendicitis in females.[13] Gupta et al study documented positive predictive value of 85% at score >7.[14] But in another study conducted by Khalil et al positive predictive value was found to be 83.5% in adults.[15] Another study conducted by Pruekprasert et al reported sensitivity of >7 score of 79% while those who were operated upon based on surgeons clinical experience the sensitivity was found to be 96% while in our study 91% sensitivity was seen on the basis of clinical experience irrespective of score.[16]

In this study, the rate of negative appendectomy for scores above 7 was just 1.8%, with only one patient undergoing surgery for a non-inflamed appendix—closely aligning with findings by Melek et al., who observed zero false positives at this threshold.[13] Whereas, Khalil et al reported it to be 15.6%.[15] In another study conducted by Sangoli et al negative appendectomy rate was 11%.[17] The fact that our study was carried out in a center that receive a lot of referrals might be the cause of very low negative appendectomy rate: as mostly the cases with high suspicion are the ones referred.

CONCLUSION

Clinical assessment including a precise history and comprehensive examination is the most important step in reaching the diagnosis of appendicitis. Use of Alvarado scoring system to guide this assessment makes diagnosis accurate especially at both extremes of the scale. However in equivocal cases discerning the positive cases can be difficult so a cut off of >5 should be used to increase the sensitivity and accuracy: this signifies that different cut-offs for different populations might be the way to go.

CONFLICT OF INTEREST

The authors declare no conflict of interest.

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AUTHORSHIP AND CONTRIBUTION DECLARATION	
1	**Muhammad Haroon Malik:** Data collection.
2	**Fazli Junaid:** Concept, design.
3	**Mumtaz Ali Khan:** Drafting.
4	**Mukhtiar Ahmed:** Literature review.
5	**Nadia Qaisar:** Data analysis.
6	**Talat Shahzad:** Critical revisions.