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Original Research Article

Evaluating the efficacy of Modified Alvarado Scoring System in diagnosing Acute Appendicitis in the Emergency Department

Goutham P. Selvam[1], Ramya Ramakrishnan[1], Srihari Cattamanchi[2], Jagadeesan Subramanian[2], Ramakrishnan V. Trichur[2]

[1]Department of Surgery, Sri Ramachandra Medical College and Research Institute, Porur, Chennai - 600116. T.N. India.
[2]Department of Emergency Medicine, Sri Ramachandra Medical College and Research Institute, Porur, Chennai – 600116. T.N. India.

***Corresponding author**
Cattamanchi Srihari
Email: srihari@cattamanchi.in

Abstract: Acute Appendicitis is a common surgical case a surgeon confronts in the Emergency Department (ED). Early diagnosis is essential to prevent morbidity and mortality in patients with acute appendicitis. The aim of this study was to evaluate the efficacy of the Modified Alvarado Scoring System in diagnosing Acute Appendicitis in the ED. This was a prospective, observational study of patients presenting with complaints of acute pain in right lower abdomen to the ED. All consecutive patients of both sexes, ≥ 18 years of age, and presenting with a history of right lower abdomen pain were included in the study. Patients with right lower abdomen pain diagnosed to have urological or gynecological pathology or a mass in the right iliac fossa were excluded. Patients with suspected acute appendicitis were assessed using Modified Alvarado Scoring System. Treatment decision was made by the treating surgeon. HPE reports of all the patients were recorded. On analyzing the results, a total of 60 patients were enrolled. Modified Alvarado score showed that 76.3% (45) patients were positive for acute appendicitis, whereas the HPE report showed 74.5% (44) were positive for acute appendicitis, with a sensitivity of 90.9%, specificity of 66.66%, PPV of 88.88%, NPV of 71.42% and a negative appendectomy rate of 16.6%. The comparison was statistically significant with a p-value of 0.001. In conclusion, the Modified Alvarado Score is a swift, simplistic, and dependable diagnostic modality in the diagnosis of Acute Appendicitis. Being non-invasive, it is a practical and economical scoring system which improves diagnostic accuracy of acute appendicitis in the ED.

Keywords: Modified Alvarado Score, Acute Appendicitis, Emergency Department, Diagnosing Appendicitis, Modified Alvarado Scoring System, Diagnostic Criteria.

INTRODUCTION

Diseases of the appendix and the surgeries involving the same are amongst the commonest encountered in surgical practice. The appendix in man is a mysterious structure. There are various speculations that it may be the analogue of the immunologically important "Bursa of Fabricius" in Avians [1]. Though often considered as a degenerative vestigial structure, it must be pointed out that it has a good blood supply and histological differentiation. When this organ gets inflamed, the consequences can be fatal if ignored, for this may lead to gangrene, perforation, or generalized peritonitis. The mainstay of treatment is early surgery that improves the prognosis.

Acute Appendicitis is one of the common diagnostic problems a surgeon is confronted with, in the Emergency Department (ED). The clinical picture may not be classical, and the policy of early operation in such cases may lead to many normal appendices being removed. Early diagnosis is a primary goal to prevent morbidity and mortality in a patient with an acutely inflamed appendix. Even though we have an armamentarium of investigations available to diagnose acute appendicitis, improvement in outcome has not been shown with the routine use of new technology. Hence, appendicitis continues to be diagnosed solely on clinical and laboratory findings.

Scoring systems are valuable and valid instruments for distinguishing between acute appendicitis and non-specific abdominal pain. At present many scoring systems are available for the diagnosis of acute appendicitis, but they suffer from poor sensitivity and specificity. Alvarado score is one of the scoring systems [2]. As Alvarado score is purely based on the history, clinical signs, symptoms, and laboratory tests like differential leucocyte count and the left shift of neutrophil maturation, the score is very easy to apply and implement in the ED. Kalan *et al.* [3], dropped the left shift of neutrophil maturation from the Alvarado score due to non-availability of this test on an

emergency basis and developed the modified Alvarado scoring system.

The aim of this study was to evaluate the efficacy of the Modified Alvarado Scoring System in diagnosing Acute Appendicitis in the Emergency Department, assess the sensitivity and specificity of the score and to determine various presentations of acute appendicitis to the ED.

MATERIALS AND METHODS

Study Design and Population

A prospective, observational study of patients presenting with complaints of acute pain in the right lower abdomen to the ED of a tertiary care university teaching hospital in Chennai, India. The study was conducted over a period of 30 months from April 2007 to September 2009. All consecutive patients of both sexes, ≥ 18 years of age, and presenting with a history of right lower abdomen pain were included in the study. Patients with right lower abdomen pain who were subsequently diagnosed to have urological or gynaecological pathology were excluded. Patients with mass in the right iliac fossa were also excluded.

Methodology

For all patients presenting to the ED with right lower abdominal pain, a thorough clinical examination was done, by the emergency physician, along with total leucocyte count. The patient's details were recorded in a preformatted Proforma. Patients with suspected acute appendicitis were assessed using Modified Alvarado Scoring System (Table 1.). Each of the preoperative signs and symptoms was awarded points in the Modified Alvarado Scoring System. Treatment options were decided by the treating surgeon. After an appendectomy, the specimens were sent for Histopathological examination (HPE). HPE reports of all the patients were collected and recorded in the proforma.

Table-1: Modified Alvarado Scoring System

SYMPTOMS	SCORE
Tenderness in the Right Iliac Fossa	2
Leucocytosis (>10 x 10^9 /L)	2
Migratory Right Iliac Fossa Pain	1
Elevated Temperature (>37^0C)	1
Nausea / Vomiting	1
Anorexia	1
Rebound Tenderness in Right Iliac Fossa	1
TOTAL	**9**
Modified Alvarado Score Interpretation	
Scores 1 - 4: Not likely to have appendicitis, No Surgery.	
Scores 5 - 6: To have findings compatible with appendicitis but not convincing to warrant surgery, needs observation in ward.	
Scores 7 - 8: To have probable Acute Appendicitis, needs surgery.	
Scores 9: Almost definitive diagnosis of Acute Appendicitis warrants surgery.	

Alvarado scoring system [2] is based on the eight predictive factors useful in making the diagnosis of acute appendicitis. They are a). Localized tenderness in the right lower abdomen, b). Leukocytosis, c). Migration of pain, d). Shift to the left, e). Temperature elevation, f). Nausea/vomiting, g). Anorexia, and h). Rebound tenderness in right iliac fossa. Alvarado scoring system is a practical diagnostic score that helps in interpreting the complex picture of acute appendicitis.

The modified Alvarado score [3] is same as the original Alvarado Scoring system except one laboratory finding "Shift to the left of neutrophil maturation" (Score 1) is excluded (Table 1.). Hence the score was calculated out of 9 rather than 10. However, excluding shift to left of neutrophil did not alter the diagnostic accuracy of the scoring system [3]. A modified Alvarado score ≥ 7 denotes the patients need surgery for acute appendicitis and a score < 7 indicated patient does not need surgical intervention but needs to be admitted and kept under observation.

Data Analysis

The data collected in the preformatted proforma were first entered into a spreadsheet (Microsoft Excel 2010; Microsoft Corporation, Redmond, WA). For categorical variables, descriptive analysis like frequency, and percentage were calculated. The sensitivity, specificity, positive predictive value (PPV), negative predictive value (NPV), and the rate of negative appendectomy were analyzed to assess the predictive accuracy of the study outcome using the area under the receiver-operating characteristic (ROC) curve. A p-value of > 0.05 was considered as statistically significant. Statistical analysis was done using statistical software (SPSS version 19.0; IBM Co., Armonk, NY, USA). A written consent was taken from the patient or their attendant in both English and their mother tongue.

RESULTS

A total of 60 patients were enrolled in the study, out of which 48.3% were male, and 51.7% were females. The maximum number of patients, 43.3% were in the age group of 21 to 30 years of age (Table 2.). Leukocyte count was less than 10,000 in 53.3% of the patients and more than 10,000 in 46.7% patients. Among the 60 patients, 1.7% patients had a modified Alvarado score between 1 to 4, 21.6% had a score of 5 to 6, 50% had a score of 7 to 8 and 26.7% had a score of 9. Modified Alvarado score was positive (score ≥ 7) in 76.7% of patients and negative (score < 7) in 23.3% patients.

Out of the 60 patients, Emergency Open Appendectomy was performed in 68.3% patients, Emergency Laparoscopic Appendectomy was performed in 30% patients, and Appendicular Abscess Drainage was done in 1.7% patients. Among the 60

patients who had surgery, Lanz incision was carried out on 58.3% patients, Laparoscopic Appendectomy incision was performed in in 30% patients, Mc Burney's incision was made on 10% patients, and Lower Midline incision was performed in 1.7% patients. Intra-operative findings showed 88.3% patients had Inflamed Appendix, 5% patients had Gangrenous Appendix, 5% patients had Perforated Appendix, and 1.7% had Appendicular abscess.

Table-2: Various Presentations of Acute Appendicitis

	No of patients (n = 60)	Percentage (%)
Age		
< 20 years	6	10
21 – 30 years	26	43.3
31 – 40 years	16	26.7
41 – 50 years	6	10
> 50 years	6	10
Gender		
Male	29	48.3
Female	31	51.7
Leucocyte Count		
< 10,000	32	53.3
> 10,000	28	46.7
Modified Alvarado Score		
1 – 4	1	1.7
5 – 6	13	21.6
7 – 8	30	50
9	16	26.7
Modified Alvarado Score Interpretation		
Positive (Score > 7)	46	76.7
Negative (Score < 7)	14	23.3
Management		
Emergency Open Appendectomy	41	68.3
Emergency Laparoscopic Appendectomy	18	30
Abscess Drainage	1	1.7
Type of Incision		
Lanz	35	58.3
McBurney's	6	10
Lower Midline	1	1.7
Laparoscopic Appendectomy	18	30
Intra Operative Finding		
Inflamed	53	88.3
Gangrenous	3	5
Perforated	3	5
Appendicular Abscess	1	1.7
Position of the Appendix		
Retrocaecal	49*	81.7
Pelvic	7*	11.6
Preileal	2*	3.3
Paracolic	1*	1.7
Histopathology		
Acute Appendix	44*	74.6
Normal Appendix	14*	23.7
Mucocele of Appendix	1*	1.7

* n = 59 instead of 60, as only 59 patients had appendectomy, and one patient underwent drainage of the appendicular abscess

On analyzing the position of the Appendix, 81.7% had a retrocaecal appendix, 11.6% had their appendix in the pelvic area, 3.3% had a preileal appendix, and 1.7% had an appendix in the paracolic position. The HPE of the specimens reported that 74.6% patients had acute appendicitis, 23.7% patients had a normal appendix, and 1.7% had a mucocele of the appendix. One patient had an appendicular abscess and managed with abscess drainage instead of surgical removal.

Modified Alvarado score showed 45 patients were positive for acute appendicitis and 14 were negative. However, the HPE report showed 44 were

positive for acute appendicitis, and 15 were negative (Table 3.). On comparing the diagnosis by Modified Alvarado Score and HPE using ROC curve, the area under the curve was 78.8% with a sensitivity of 90.9%, specificity of 66.66%, PPV of 88.88%, NPV of 71.42% and a negative appendectomy rate of 16.6%. The comparison was 99.9% statistically significant with a p-value of 0.001 (Table 4.).

In males, both the modified Alvarado score and HPE showed 22 patients were positive for acute appendicitis, and six patients were negative (Table 3.). The ROC curve analysis showed the area under the curve was 89.4% with a sensitivity of 95.5%, specificity of 83.3%, PPV of 95.5%, NPV of 83.3% and a negative appendectomy rate of 8.3%, which was 99.9% statistically significant with a p-value of 0.001 (Table 4.).

In females, the modified Alvarado score showed 23 patients were positive for acute appendicitis, and eight patients were negative, whereas the HPE showed 22 patients were positive for acute appendicitis, and nine patients were negative (Table 3.). The ROC curve analysis showed the area under the curve was 71% with a sensitivity of 86.4%, specificity of 55.6%, PPV of 82.6%, NPV of 62.5% and a negative appendectomy rate of 8.3%, which was 95% statistically significant with a p-value of 0.05 (Table 4.).

Table-3: Comparison of Modified Alvarado Score diagnosis vs Histopathological Findings

Gender	Modified Alvarado Score (n= 59)*		Histopathology for Acute Appendicitis (n = 59)*	
	Positive	Negative	Positive	Negative
Females	23 (74.2%)	08 (25.8%)	22 (70.9%)	9 (29%)
Males	22 (78.6%)	6 (21.4%)	22 (78.6%)	6 (21.4%)
Total	45 (76.3%)	14 (23.7%	44 (74.5%)	15 (25.4%)

- Number patients and in parenthesis percentage.
* n = 59 instead of 60, as only 59 patients had appendectomy, and one patient underwent drainage of the appendicular abscess

Table-4: Statistical Analysis of Modified Alvarado Score diagnosis vs Histopathology

Gender	Area Under the Curve	Sensitivity	Specificity	PPV	NPV	Negative Appendectomy Rate	Statistical Significance p-Value
Females	71%	86.4%	55.6%	82.6%	62.5%	8.3%	0.05
Males	89.4%	95.5%	83.3%	95.5%	83.3%	8.3%	0.001
Total	78.8%	90.9%	66.66%	88.88%	71.42%	16.6%	0.001

DISCUSSION

Results of our study show that acute appendicitis was most common in the 21 to 30 years' age group (43.3%). The next common group was 31 to 40 years old (26.7%). Previous studies have shown that appendicitis is more common in the 20 to 30 years of age group [4-7].

Acute appendicitis diagnosis remains a challenging task for the surgeons. A negative appendectomy rate of 20 to 40% is not an unusual finding in medical literature [3]. Negative appendectomy rate in this study was 16.6%, which was equal to both males and females (8.3% each).

The percentage of normal appendectomies in various series differs from eight to 33% [8, 9]. Lone *et al*. [10] in his study observed negative appendectomy rate as 17%. Owen *et al*. [11], observed in their prospective study of 215 patients (including children), the use of Alvarado score decreased an unusual high false positive appendectomy rate from 44% to 14%. For the entire modern era of surgery many surgeons opined that maximum 15 to 20% negative appendectomy is acceptable [12]. Removal of normal appendices is inevitable to lower the rate of perforation and consequent mortality. On the other hand, unnecessary appendectomy carries long-term risks for the patient.

Talukder *et al*. [4] noted a sensitivity of 89% and specificity of 68% with a negative appendectomy rate of 16%. Gujar N *et al*. [5], in their study observed a sensitivity of 65.62% and specificity of 91.67% with a negative appendectomy rate of 8.1%. Fengo *et al*. [13] reported a sensitivity of 73% and a specificity of 87% with a negative laparotomy rate of 17.5%. In this study, the sensitivity was 95.5% in males, and 86.4% in females and the combined sensitivity was 90.9%, with a negative appendectomy rate of 16.6%.

This study also reveals that modified Alvarado scoring system was more helpful in male patients by showing a high accuracy rate as compared to female patients. Similarly, Lone *et al*. [10], has demonstrated in their study that sensitivity was more in male patients than female patients. In female patients, additional investigations may be required to confirm the diagnosis, which is supported by other studies too [14].

CONCLUSION

The Modified Alvarado Score is a swift, simple and dependable diagnostic modality in the diagnosis of Acute Appendicitis. Being non-invasive, it is a practical and economical scoring system which improves diagnostic accuracy of acute appendicitis in the ED, and consequently reduces negative appendectomy and complication rates.

The modified Alvarado Score had a high sensitivity and low specificity with a high positive predictive value. Our negative appendectomy rate was low which was found to be equal for both sexes. We observed a female predominance and an increased prevalence of appendicitis among 21-30 years of age. Retrocaecal position is the most common location of appendix.

The patients with scores more than or equal to seven are almost guaranteed to have appendicitis and should undergo immediate surgery. Patients with a score of less than seven should be observed and evaluated every four to six hours. During revaluation, if the score increases or remains the same, then it is at the surgeon's discretion whether to operate. Patients with scores less than or equal to four can be discharged after receiving initial conservative treatment, counselling and advise to report immediately if the symptoms persist or the condition worsens.

However, in the diagnosis of acute appendicitis, signs, symptoms or laboratory studies are not 100% reliable. In this study, the accuracy of the diagnosis of acute appendicitis using the Modified Alvarado Scoring system was trusty and admissible for higher scores, whereas admission and observation are warranted for patients with lower scores. The modified Alvarado score is a guide for the ED physician, evaluating the patient's need for surgery or observation.

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