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Exploring the Diagnostic Accuracy of Alvarado Score in Acute Appendicitis: A Prospective Study From Western Maharashtra

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ABSTRACT
Acute abdominal pain poses a daily challenge for surgeons worldwide, encompassing various potential causes across medical specialties. The alvarado scoring system aids clinical diagnosis but leads to high negative appendectomy rates. This study evaluates its utility compared to histopathology in enhancing early diagnosis and reducing unnecessary surgeries, especially in settings with limited imaging resources. A prospective observational study at department of general surgery, Dr. Vithalrao Vikhe Patil Foundation's Medical College, ahmednagar, from February 2022-2023 involved 100 non-elective patients aged 1-70 with suspected acute appendicitis undergoing appendicectomy with histopathological examination. Exclusion criteria included specific conditions and admission details were documented, including medical history, physical examination, clinical indicators and alvarado scores. Clinical indicators included right iliac fossa tenderness, migratory pain, anorexia, nausea, vomiting, fever and laboratory results. Histopathological diagnoses comprised acute appendicitis, gangrenous acute appendicitis, perforated acute appendicitis and normal appendix. The study achieved a 7% negative appendectomy rate with the alvarado score accurately identifying acute appendicitis in 93% of patients. Negative appendectomy rates were higher among females (9.83%) than males (2.56%). The alvarado score demonstrated robust diagnostic performance with sensitivity, specificity, positive predictive value, negative predictive value and diagnostic accuracy of 92.47%, 85.71%, 98.85%, 46.15% and 92.00%, respectively. Clinical indicators, including pain migration and anorexia, underscored the alvarado score's effectiveness. Histopathological analysis categorized patients into appendicitis and regular appendix groups. With a threshold of 7 the alvarado score accurately identified acute appendicitis, resulting in a low negative appendectomy rate. Higher negative appendectomy rates were observed in females. Acute appendicitis, diagnostic accuracy, alvarado Score, appendicitis diagnosis, clinical scoring system. Exploring the diagnostic accuracy of alvarado acore in acute appendicitis.

INTRODUCTION

The daily challenge of acute abdominal pain for surgeons worldwide, particularly in emergencies, involves various potential causes across medical specialties[1]. Non-specific abdominal pain (NSAP) diagnoses account for 13-35% and up to 70% of pediatric cases, often challenging timely intervention[2] Swiftly identifying acute abdomen cases is essential as the abdomen's complexity often presents surprises[1-3] Despite medical advancements, meticulous abdominal examination remains crucial. Acute appendicitis a common cause of acute abdomen has an incidence of 1.17 per 1000 with a lifetime risk of 8.6% in males and 6.7% in females. Diagnosis, especially in children, women and the elderly, can be intricate despite medical progress[4].The Alvarado scoring system aids clinical diagnosis by considering symptoms, signs and lab values[5]. However, negative appendectomy rates remain high, impacting resources and morbidity[3-4] While imaging techniques like CT and MRI have limitations, the alvarado system's effectiveness warrants evaluation to enhance early diagnosis and reduce unnecessary surgeries[6]. With limited region-specific research a prospective study can validate its utility compared to histopathology, offering valuable insights into acute appendicitis diagnosis in settings with limited imaging resources.

MATERIALS AND METHODS

A prospective observational study was conducted from February 2022-2023 at Department of General Surgery, Dr. Vithalrao Vikhe Patil Foundation's Medical College, Ahmednagar. It involved 100 patients, aged 1-70 years, presenting non-electively with clinical features suggestive of acute appendicitis who subsequently underwent appendicectomy with histopathological examination.

Patients arriving at the Emergency/General Surgery Department of Dr. Vithalrao Vikhe Patil Foundation's Medical College Ahmednagar with right iliac fossa (RIF) pain and suspected acute appendicitis were included. Patients with non-RIF pain or prior admissions for different issues were excluded. Additionally those with abdominal pain over five days, suspected appendicular lump/mass, peritonitis signs, pregnancy, immunocompromised status, mental retardation, prior gastrointestinal surgery, urolithiasis, or pelvic inflammatory disease were excluded.

Admission details were documented, encompassing medical history and physical examination. Clinical indicators such as right iliac fossa tenderness, migratory pain, anorexia, nausea, vomiting, fever and laboratory results were noted. Alvarado's scoring was conducted during admission and reviewed 6-8 hrs later. Final scoring was evaluated and documented[7] (Table 1-2).

Interpretation of Alvarado score:

- Score Interpretation
- Low probability of appendicitis
- Compatible with the diagnosis of acute appendicitis
- Probable appendicitis
- Very probable appendicitis

Line of management: Plan of management was decided according to the interpretation of alvarado score as follows, score 1-4, low probability of appendicitis, 5-6, compatible with the diagnosis of acute appendicitis and 7-8 probable appendicitis, 9-10 very probable appendicitis.

Definition of parameters:

- **Negative appendectomy:** Surgery performed for suspected appendicitis where the appendix is normal histologically
- **Gold standard:** This study's valid outcome reference (histopathological examination)
- **Leukocytosis:** Total leukocyte count exceeding 10,000 mm^{-3}
- **Fever/elevation of temperature:** Temperature equal to or exceeding 37.3°C (99°F)
- **Left shift of neutrophils:** Total leukocyte count with neutrophil count of 75% or more

Ethical aspects: Prior to the commencement of the study, all enrolled individuals were given informed written consent documents. Utmost confidentiality regarding their personal information was upheld during the research. The study obtained approval from the Institutional Ethics Committee prior to its initiation.

Statistical analysis plan: Categorical variables are presented as patient counts and percentages, then compared between groups using either Pearson's Chi-Square test for Independence of Attributes or Fisher's Exact Test as appropriate. Analysis was performed using the statistical software SPSS version 20. A significance level of 5% ($p<0.05$) was adopted. The derived sensitivity, specificity, positive predictive value (PPV) and negative predictive value (NPV) will explain the alvarado score's effectiveness in distinguishing acute appendicitis from ailments with comparable clinical manifestations.

RESULTS

We have included 100 cases in the present study. The ratio of females to males was 1.564-1. The average age was 26.45 years with a standard deviation of 15.13. The highest age was 65 while the lowest was two years. (Table 3) The distribution of scoring system parameters is as follows Migration of pain to RLQ was observed in 70 cases (70.00%), anorexia in 90 cases

Table 1: Alvarado scoring system parameters

Parameters	Score
Symptoms	
Migration of pain to RLQ	1
Anorexia	1
Nausea-vomiting	1
Sign	
Tenderness in RLQ of abdomen	2
Rebound tenderness	1
Elevation of temperature (>37.3°C or 99°F)	1
Laboratory findings	
Leucocytosis (>10000 $mm^{-3)}$	2
Shift of neutrophils to left (>7500 $mm^{-3)}$	1
Total	10

Table 2: Line of management

Score	
1-4	Kept under observation and discharged if stable
5-6	Managed conservatively with iv fluid, antibiotics, analgesics and discharged if stable and followed up in OPD
7-10	Included in study and underwent open appendicectomy

Table 3: Demographic particulars of the present sample

Demographic particulars	Frequency	Percentage
Age group		
1-10	17	17.00
11-20	23	23.00
21-30	27	27.00
31-40	18	18.00
41-50	7	7.00
51-60	5	5.00
>60	3	3.00
Gender		
Male	39	39.00
Female	61	61.00

Table 4: Distribution of the signs and symptoms based on alvarado scoring system

Parameters of scoring system	Frequency	Percentage
Migration of pain to RLQ	70	70.00
Anorexia	90	90.00
Nausea-vomiting	85	85.00
Tenderness in RLQ of abdomen	100	100.00
Rebound tenderness	75	75.00
Elevation of temperature (>37.3°C or 99°F)	81	81.00
Leukocytosis (>10000 $mm^{-3)}$	83	83.00
Shift of neutrophils to left (>7500 mm^{-3})	89	89.00

Table 5: Distribution based on intra operative findings

Operative findings	Frequency	Percentage
Inflamed and perforated appendix	7	7.0
Inflamed and gangrenous appendix	3	3.0
Inflamed appendix	83	83.0
Normal appendix	7	7.0
Total	100	100.00

Table 6: Distribution based on the histopathological findings

Histopathological diagnosis	Frequency	Percentage
Acute appendicitis	83	83.0
Acute appendicitis (gangrenous)	3	3.0
Acute appendicitis (perforated)	7	7.0
Normal appendix	7	7.0
Total	100	100.0

Table 7: Frequency distribution of alvarado score in the study

Alvarado score	Frequency	Percentage
<7	13	13.0
>7	87	87.0
Total	100	100.0

Table 8: Distribution of histopathological diagnosis according to alvarado Score

	Alvarado score		
Histopathological diagnosis	< = 7	>7	Total
Normal appendix	6(46.15)	1(1.15)	7(7)
Acute appendicitis	7(53.85)	86(98.85)	93(93)
Total	13(100)	87(100)	100(100)

(90.00%), nausea-vomiting in 85 cases (85.00%), tenderness in RLQ of abdomen in all 100 cases (100.00%), rebound tenderness in 75 cases (75.00%), elevation of temperature (>37.3°C or 99°F) in 81 cases (81.00%), leukocytosis (>10000 mm^{-3}) in 83 cases (83.00%) and shift of neutrophils to the left (>7500 mm^{-3}) in 89 cases (89.00%) (Table 4). During the surgical procedures the following operative findings were observed seven cases (7.0%) presented with an inflamed and perforated appendix, three patients (3.0%) exhibited an inflamed and gangrenous appendix while the majority, comprising 83 patients (83.0%), displayed inflammation of the appendix. Additionally, seven cases (7.0%) had a normal appendix, indicating the absence of inflammation or pathological changes in this anatomical structure (Table 5). The distribution of histopathological diagnoses is as follows. Acute appendicitis was observed in 83 cases (83.0%), gangrenous acute appendicitis in 3 cases (3.0%), perforated acute appendicitis in 7 cases (7.0%) and normal appendix in 7 cases (7.0%) (Table 6). The distribution of Alvarado scores is as follows Scores of < = 7 were present in 13 cases (13.0%) while scores of >7 were found in 87 cases (87.0%) (Table 7-8). After receiving the histopathological examination reports, we categorized the patients into two groups based on the findings: those with a normal appendix and those diagnosed with acute appendicitis. Our study revealed accurate identification of acute appendicitis in 93 patients (93%) through applying the Alvarado scoring system with a cut-off of 7. Conversely, seven patients (7%) exhibited normal appendices upon histopathological evaluation. Thus, the negative appendectomy rate in our study stood at 7%. Among these cases with average histopathological outcomes, six were female and one was male. The negative appendectomy rate among female patients reached 9.83% while among male patients it was 2.56%. In our investigation the alvarado score's comprehensive sensitivity, specificity, positive predictive value, negative predictive value, and diagnostic accuracy using a threshold of 7 were observed to be 92.47%, 85.71%, 98.85%, 46.15% and 92.00%, respectively.

DISCUSSION

Numerous diagnostic scoring systems have been developed to mitigate unnecessary appendectomies and improve the precision of diagnosing appendicitis. Notably, the comprehensive alvarado scoring system, introduced in 1986, stands out as a practical tool for interpreting acute appendicitis cases[7-8] Initially designed to address high false-positive diagnostic rates, the Alvarado system's simplicity, applicability,

and suitability for emergency surgical contexts have propelled its widespread adoption[5-9]. The prevalent occurrence of appendicitis falls predominantly within the 10-20-year age bracket, carrying a lifetime risk of 8.6% for males and 6.7% for females[9]. Global data reflects a peak incidence among individuals aged 15-19 a trend paralleled in the current study[10].

In this study, employing an alvarado score cut off of 7 the diagnostic performance metrics revealed a sensitivity of 92.47%, specificity of 85.71%, positive predictive value of 98.85%, negative predictive value of 46.15% and diagnostic accuracy of 92.00%. These findings correlate with similar investigations. Bouali *et al*.[11] reported sensitivity, specificity, positive predictive value, negative predictive value, positive likelihood ratio and negative likelihood ratio of 94.9%, 72.7%, 98.4%, 44.4%, 3.48 and 0.07, respectively. Al-Tarakji[12] observed a sensitivity of 66.4%, specificity of 69.8%, PPV of 98.1%, NPV of 8.1% and accuracy of 66.5%. Gupta S's meta-regression study revealed a significant positive coefficient, indicating a cause and effect relationship between high Alvarado scores and histologically confirmed appendicitis[13]. This alignment is also seen in Srivastava *et al*. work[14] The Alvarado score is strongly associated with histopathological findings "Increased scores corresponded with higher instances of confirmed acute appendicitis." Additionally, employing Alvarado's clinical scoring system for patients exhibiting acute appendicitis symptoms in an emergency helps avert incorrect negative surgeries.

Limitations of the study include the relatively small sample size, which could affect the generalizability of the findings. Additionally the study's single-center design might limit the applicability to broader populations. The retrospective nature of specific data collection could introduce information bias. Furthermore, external factors such as variations in clinical practice and patient characteristics, might influence the outcomes. Lastly the study's time frame may not fully capture potential long-term effects or changes in diagnostic approaches.

CONCLUSIONS

Scoring system parameters highlighted prevalent clinical indicators such as pain migration, anorexia, RLQ tenderness and more, showcasing the system's effectiveness. Histopathological analysis categorized patients into appendicitis and regular appendix groups. Using a threshold of 7 the Alvarado score accurately identified acute appendicitis in most cases, resulting in a fraction of cases with normal appendices and a corresponding fraction of negative appendectomy rate. Among patients with normal appendices a fraction were female and a fraction male with higher female negative appendectomy rates. Notably, Alvarado's diagnostic metrics displayed robust performance.

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