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Incidence of Acute Appendicitis with Alvarado Score between 5 and 7

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ABSTRACT

Background: The Alvarado score is a widely used clinical tool for diagnosing acute appendicitis, especially in emergency settings. However, its diagnostic accuracy in patients with intermediate scores (5–7) remains uncertain. *Aim:* To assess the incidence of confirmed acute appendicitis in patients with Alvarado scores between 5 and 7 and to evaluate the reliability of the Alvarado scoring system in this diagnostic range.
Patients and Methods: A prospective observational study was conducted 228 patients presenting with symptoms and signs of acute appendicitis to the emergency department at t Imam Hussain Medical City during the period from 1st January 2024 31st December 2024. All patients underwent clinical evaluation using the Alvarado scoring system and were subsequently treated surgically. Final diagnoses were confirmed through operative and histopathological findings. Sensitivity, specificity, and predictive values of the score were calculated.
Results: Of the 228 patients, 59 (25.88%) had Alvarado scores between 5 and 6, while 169 patients (74.12%) had a score of 7. According to operative findings, 198 patients (86.84%) were confirmed to have acute appendicitis, while 30 patients (13.16%) had other pathologies and appendicular mass. The overall sensitivity and specificity of the Alvarado score were 83.33% and 86.87%, respectively. However, in, the negative predictive value was notably lower at 45.72%, indicating limited reliability in excluding appendicitis in this subgroup.
Conclusion: Although the Alvarado score shows good overall diagnostic performance, its predictive accuracy in the 5–7 score range is limited. Patients with intermediate scores require further diagnostic evaluation using imaging and close clinical monitoring to avoid misdiagnosis or unnecessary surgery.
Keywords: Alvarado score, acute appendicitis, diagnostic accuracy

INTRODUCTION

Globally, acute appendicitis represents a prevalent surgical emergency, with an estimated lifetime incidence of 1 in 7, indicating that approximately 6% of individuals will experience an episode of this condition throughout their lives (1). The diagnosis of this ailment is particularly challenging, especially during the initial stages, when the classical clinical signs and symptoms tend to be rather insidious (2). Various pathological processes can simulate the clinical presentation of acute appendicitis, as there exists a multitude of etiologies resulting in

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discomfort localized to the right iliac fossa, particularly among female patients (3).

It has been documented that a considerable number of patients who undergo appendectomy exhibit negative findings upon histopathological examination of the resected appendix, which serves as the definitive diagnostic criterion for appendicitis (4). The removal of an intact appendix imposes significant burdens on both patients and healthcare resources (5). Nevertheless, the early identification of the condition coupled with timely surgical intervention has emerged as the most critical factors in mitigating morbidity, potential mortality, duration of hospitalization, and overall treatment expenditures (6).

Numerous scoring systems have been developed to facilitate the early diagnosis and timely management of acute appendicitis. These scoring systems are recognized as valuable and reliable tools for distinguishing between acute appendicitis and nonspecific abdominal discomfort (2). One notable example is the Alvarado scoring system, which integrates histopathological data, physical examination findings, and select laboratory tests, and is characterized by its ease of application (6). Nonetheless, a definitive diagnosis can ultimately be established during surgical intervention and subsequent histopathological evaluation (7).

The present study aimed to assess the incidence of confirmed acute appendicitis in patients with Alvarado scores between 5 and 7 and to evaluate the reliability of the Alvarado scoring system in this diagnostic range.

PATIENTS AND METHODS

Study Population

This is a prospective observational study including a total of 228 patients presenting with symptoms and signs of acute appendicitis to the emergency department at t Imam Hussain Medical City during the period from 1st January 2024 31st December 2024. These include acute onset abdominal pain mainly in the right lower quadrant, nausea, vomiting, anorexia, elevated temperature, and right lower quadrant tenderness and rebound tenderness (by physical examination). The study was approved by Arab Council for Health Specializations. The study included patients of any age group and both sexes that presenting to the emergency department sign and symptoms indicating acute appendicitis and operated with appendectomy. Patients with no documented Alvarado score, those who did not have an abdominal ultrasound, pregnant women, patients taking nonsteroidal anti-inflammatory drugs and those with Alvarado score <5 and >7 were excluded from the study.

A verbal consent from each participant was obtained prior to data collection after explaining the aim of study. The confidentiality of data throughout the study was guaranteed and the patients were assured that data will be used for research purpose only.

Data Collection

All included patients were admitted after initial assessment in the emergency department and demographic characteristics including age and sex, and baseline investigations including total white blood cell (WBC) count, neutrophil % and hemoglobin (Hb) concentration were reported.

Alvarado Score

The Alvarado score was calculated based on clinical symptoms (migration of pain, anorexia, nausea/vomiting), signs (tenderness in the right lower quadrant, rebound tenderness, elevated temperature), and laboratory findings (leukocytosis and left shift of neutrophils). The sum of the score was assigned to each patient.

Ultrasonography

US examination was performed using ultrasound device (Philips HD 11xe 2011), with 5-7.5 MHz probe. The criteria for positivity-included visualization of non-compressible tubular and blind-ended non-peristaltic structure with diameter of 6 mm or more in right lower quadrant, the demonstration of Appendicoliths, Probe tenderness, increased echogenicity of the peri-appendiceal fat and free intraperitoneal fluid particularly in right iliac fossa (RIF) or pelvis. The criteria of negativity were non-visualization of appendix or visualization of normal appendix with or without alternative diagnosis (8).

Surgical Technique

Open appendectomy was executed via a right lower quadrant incision (commonly utilizing either a McBurney or Lanz incision) under general anesthesia. Following the incision of the skin and fascial layers, access to the peritoneal cavity was achieved, wherein the appendix was located. In instances of inflammatory adhesions, they were meticulously dissected. The mesoappendix was ligated, after which the appendix

was excised subsequent to the placement of a transfixing ligature at its base. Hemostasis was assured, and the peritoneal cavity was lavaged if any contamination was detected. The incision was sutured in layers, and the management of the wound was contingent upon intraoperative findings, with or without the use of drainage.

Laparoscopic appendectomy was conducted under general anesthesia utilizing the conventional three-port technique. Upon the establishment of pneumoperitoneum, trocars were introduced through the umbilicus, the suprapubic region, and the left lower quadrant. The appendix was identified, followed by careful dissection and sealing of the mesoappendix employing either electrocautery or clips. The base of the appendix was ligated with the use of endoloops or staplers, and the appendix was extracted through the umbilical port. The abdominal cavity was irrigated in the event of encountering purulent fluid or other forms of contamination. Hemostasis was verified, and the ports were withdrawn under direct visualization. The incisions were subsequently closed in layers, and patients were monitored in the postoperative period for any complications that may arise. The definitive diagnosis was based on the histopathological assessment of the specimen

Statistical Analysis

All data were analyzed with statistical package for social sciences (SPSS) software (version 26). Descriptive statistics were used to present the data. Continuous variables are presented as mean± standard deviation (SD); categorical variables were presented as frequencies and percentages. The diagnostic value of Alvarado and ultrasound was calculated as follow considering the surgical finding as a gold standard:

- Sensitivity in percentage: (TP/TP + FN) * 100;
- Specificity in percentage: (TN/TN+FP) * 100;
- Positive predictive value (PPV) in percentage: (TP/ TP + FP)* 100;
- Negative predictive value (NPV) in percentage: (TN/ TN +FN) * 100;
- Diagnostic accuracy in percentage: (TP + TN/ TP +TN + FP + FN) * 100.

RESULTS

Demographic Characteristics of the Patients

Table 1 presents the demographic characteristics of the 228 patients suspected to have acute appendicitis.

Table 1 - Demographic characteristics of the patients with acute appendicitis (n=228)

Variables	Category	Value
Age, years	Mean±SD	38.48±13.46
	Range	14-60
	14-30	73(32%)
	31-45	75(33.33%)
	46-60	79(34.67%)
Sex	Male	127(55.7%)
	Female	101(44.3%)

SD: standard deviation

The age distribution shows a mean age of 38.48±13.46 years, and the ages ranged from 14 to 60 years; of whom 32% were aged 14-30 years (n=73), 33.33% were 31-45 years (n=75), and 34.67% were 46-60 years (n=79). In terms of sex distribution, 127 patients (55.7%) were male, and 101 patients (44.3%) were female.

Clinical Characteristics of the Patients

Table 2 summarizes the clinical characteristics of patients. Based on the Alvarado scoring system, 169 patients (74.12%) had a score of 7 , 37patients (16.23%) had a score 5 and 22 patients (9.65%) had score 6. The mean WBC count was 12.88×10^6/L, with a range of 7.5 to 17.0, indicating a general trend of leukocytosis among patients. The mean neutrophil percentage was 76.28%, ranging from 46.7% to 85.0%. The mean Hb level was 12.5 g/dL, with values ranging from 10.1 to 15.0 g/d. Laparoscopic surgery was performed in 35 patients (15.35%) while 193 patients (84.65%) undergone open surgery.

Ultrasound Findings

According to US findings, 51 patients (22.37%) had normal appendix. Highly inflamed appendix was the

Table 2 - Clinical characteristics of the patients with acute appendicitis (n=228)

Variables	Category	Value
Alvarado score	5	37(16.23%)
	6	22(9.65%)
	7	169(74.12%)
WBC count×06/L	Mean±SD	12.88±2.42
	Range	7.5-17.0
Neutrophil, %	Mean±SD	76.28±7.1
	Range	46.7-85.0
Hb, g/dl	Mean±SD	12.5±1.43
	Range	10.1-15.0
Surgery	Laparoscopic	35(15.35%)
	Open	193(84.65%)

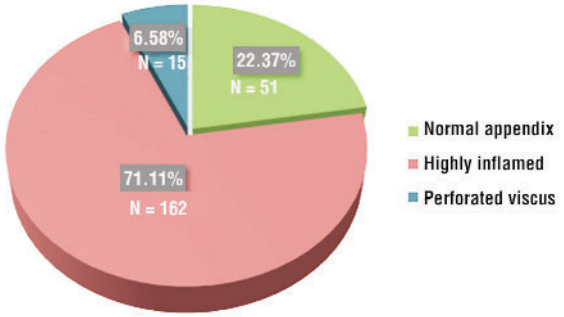

Figure 1 - Distribution of patients according to US findings

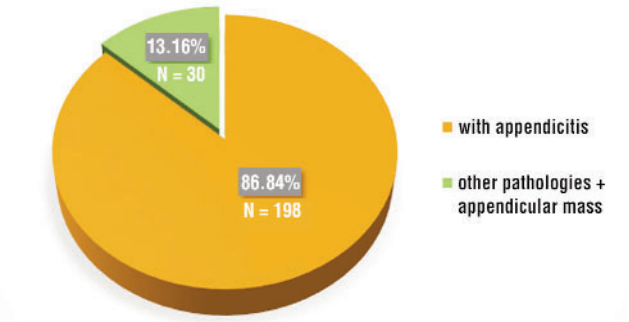

Figure 2 - The proportion of acute appendicitis according to operative findings

most common findings account for 162 patients (71.11%) and finally perforated viscus (6.58%) as shown in *fig. 1*. Accordingly, acute appendicitis was detected in 177 patients based on US.

Final Diagnosis

According to operative findings, 198 patients (86.84%) were confirmed to have acute appendicitis, while 30 patients (13.16%) had other pathologies and appendicular mass (*fig. 2*).

Non-Appendicitis Pathologies

Out of 30 patients without appendicitis, 9 (30%) were found to have ovarian cysts, 7(23.33%) had mesenteric lymphadenitis, 5(16.67%) had pelvic inflammatory disease, 5 (16.67%) had uretric colic, 3(10%) had appendicular mass, and one patients (3.33%) had Meckel's diverticulum (*fig. 3*).

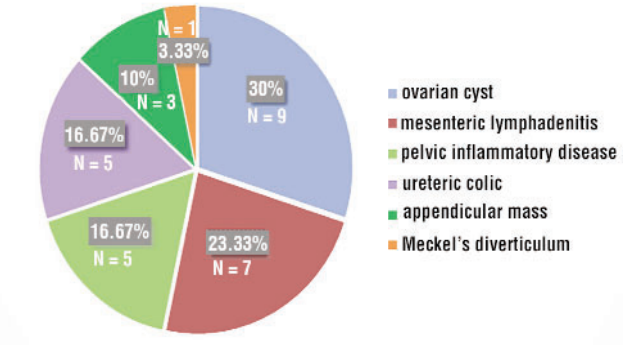

Figure 3 - Distribution of patients according to non-appendicitis pathologies

Diagnostic value of Alvarado Score

Overall diagnostic value

A total of 169 patients had Alvarado score ≥ 7 and were considered to have acute appendicitis. Among 198 patients confirmed to have acute appendicitis based on operative findings, 165 were also identified as positive for acute appendicitis using the Alvarado score. Conversely, of the 30 patients who were negative for acute appendicitis, 26 were similarly classified as negative by the Alvarado score. Accordingly, the sensitivity and specificity of Alvarado score in diagnosis of acute appendicitis will be 83.33% and 86.87%, respectively (*table 3*).

In male patients

The sensitivity and specificity of Alvarado score in diagnosis of acute appendicitis in males were 89.29% and 86.87%, respectively (*table 4*).

In female patients

the sensitivity and specificity of Alvarado score in diagnosis of acute appendicitis in males were 75.58% and 86.87%, respectively (*table 5*).

Table 3 - The overall diagnostic value of Alvarado score in detection of acute appendicitis

Alvarado score	Operative findings		Total
	Positive	Negative	
Positive (score 7)	165	4	169
Negative (score 5-6)	33	26	59
Total	198	30	228

Sensitivity = 165/ (165+33) ×100 = 83.33%
Specificity = 26/ (26+4) ×100 = 86.87%
Positive predictive value = 165/(165+4) × 100 = 97.63%
Negative predictive value = 26/(26+33) × 100 = 45.72%
Accuracy = (165+26)/(165+4+33+26)×100 = 83.77%

Table 4 - Diagnostic value of Alvarado score in detection of acute appendicitis in males

Alvarado score	Operative findings		Total
	Positive	Negative	
Positive (score 7)	100	2	102
Negative (score 5-6)	12	13	25
Total	112	15	127

Sensitivity = 100/(100 + 12) ×100 = 89.29%
Specificity = 13/(2 +13) ×100 = 86.67%
Positive predictive value = 100/(100+2) × 100 = 98.04%
Negative predictive value = 13/(13+12) × 100 = 52%
Accuracy = (100+13)/(100+1+12+13) × 100 = 88.97%

Table 5 - Diagnostic value of Alvarado score in detection of acute appendicitis in females

Alvarado score	Operative findings		Total
	Positive	Negative	
Positive (score 7)	65	2	67
Negative (score 5-6)	21	13	34
Total	86	15	101

Sensitivity = 65/(65 + 21) × 100 = 75.58%
Specificity = 13/(13 + 2) × 100 = 86.67%
Positive predictive value = 65/(65+2) × 100 = 97%
Negative predictive value = 13/(13+21) × 100 = 38.24%
Accuracy = (65 + 13)/(65 + 2 + 21 + 13) × 100 = 77.23%

Diagnostic Value of Ultrasonography

According to US findings, 177 patients were found to have acute appendicitis. Of those, 172 patients were diagnosed operatively. Alternatively, 25 patients out of 30 had a negative result for acute appendicitis. As such, the sensitivity and specificity of US in diagnosis of acute appendicitis will be 86.87% and 83.33%, respectively (*table 6*).

DISCUSSION

In spite of being the most common cause of acute abdomen, acute appendicitis remains a challenging diagnosis because it is basically a clinical diagnosis which has many clinical pictures. Thus, atypical cases present a diagnostic dilemma. Therefore, clinical diagnosis should be complemented with other diagnostic modalities. According to the result of the study, the mean age of the patients was 38.48 ± 13.46 years, with slight predominant of males over females (55.7% vs 44.3%). These results are in accordance with several pervious studies worldwide.

In an Iraqi study including, 400 patients acute appendicitis was more common in males (n=224, 56%) than females (n=176, 44%) with male to female ratio of 1.27:1. However, the highest rates of appendicitis was found in the age group of 10 to 19 years (39.5%) and the lowest was 50 and more (2.75%) (9). In an Egyptian study including 50 patients, acute Appendicitis existed more frequently in males than females (60% versus 40%). The age of patients ranged from 9 to 62 years, with the mean age was about 28 years old (10). Suboti´c et al. (11) in their study on 48 patients, 52,09% were males, and 23 (47,91%) were female.

Sex variation was attributed to the fact that female patients with right iliac fossa pain have a wide range of differential diagnoses. As a result, acute appendicitis may be over diagnosed in this gender group.

In the present study, US findings revealed highly inflamed in162 patients (71.11%,) and perforated viscus (6.58%). These findings suggest that most patients presented during the active inflammatory phase, while a smaller proportion had progressed to complicated appendicitis such as perforation. When compared with other studies, variability in sonographic findings has been reported, reflecting differences in the timing of presentation, disease progression, and patient characteristics. Al Awayshih et al. (12) included 100 Jordanian patients with acute appendicitis. The perforate viscus accounted for 4% of the patients which very close to the present study. Memon et al. (13) reported a perforation rate of 9.2% Kong et al. (14) studied 1000 patients (54% male, median age 21yrs.). Forty percent had inflamed, non-perforated appendices, and 60% had perforated appendices.

The relatively lower detection of perforation (6.58%) in the current study may indicate that most patients were diagnosed and treated before perforation occurred, or that subtle signs of perforation were difficult to visualize with ultrasound.

In the present study, the negative appendectomy rate was 13.16% which with the context of global rate

Table 6 - Diagnostic value of ultrasound in detection of acute appendicitis

Ultrasound	Operative findings		Total
	Positive	Negative	
Positive	172	5	177
Negative	26	25	51
Total	198	30	228

Sensitivity = 172/(172 + 26) × 100 = 86.87%
Specificity = 25/(25 + 5) × 100 = 83.33%
Positive predictive value = 172/(172 + 5) ×100 = 97.18%
Negative predictive value = 25/(25 + 26) ×100 = 49%
Accuracy = (172 + 25)/(172 + 5 + 26 + 25) × 100 = 86.4%

which was rates reported in the literature of 8 to 33% (15). In an Iraqi a prospective study of 225 patients, the negative appendectomy rate was 27 cases (12.0%) (16). Moreover our results is are agreement with Nasiri S et al, when he reported that the negative finding were found in rates about (11%) of the patients included in their study (17).

A much higher rate of negative appendectomy was reported in a Pakistani study (28.7%) (13). Tekeli M et al, in his study found that the incidence of negative appendectomy was more than in our study (25.3 %) (18), while In Al Hashemy AM, revealed that the incidence rate of false positive appendectomy was 27.3% (19).

In contrast, a Moroccan study including 80 patients with acute appendicitis, negative appendectomy rate was 4.8% (44). Furthermore, Akhnokh et al. (10) demonstrated that thee negative appendectomy rate in the current study was 10% which are lower than ours.

In the present study, in patients with no acute appendicitis, ovarian cysts was reported in 9 patients, mesenteric lymphadenitis in 7 patients, pelvic inflammatory disease in 5 patients, uretric colic in 5 patients, appendicular mass in 3 patients, one patients had Meckel's diverticulum. Almost similar findings were reported in the Pakistani study, where the right ovarian cysts was reported in 12.9%, mesenteric lymphadenitis in 9.6%, pelvic inflammatory disease in 9.6%, and right ureteric colic in 9.6% of the patients with non-appendicitis (13).

In the present study, the overall the sensitivity and specificity of Alvarado score in diagnosis of acute appendicitis will be 83.33% and 86.87%, respectively. the PPV and NPV were 97.63% and 45.72%, respectively. Furthermore, Alvarado score had higher sensitivity, PPV, NPV and accuracy in males (89.29%, 98.04%, 52% and 88.97%, respectively) than females (75.58%, 97%, 38.24% and 77.23%, respectively). These findings are in accordance with most previous international studies.

Gupta et al. (21) studied 50 Indian patients with acute appendicitis. The sensitivity of Alvarado score was 96.29%, specificity was 66.66%, and the positive predictive value was 92.85%, while in women group, the sensitivity was 81.8%, specificity was 66%, and positive predictive value was 81.8%.

In the study by Memon et al, the Alvarado scoring system exhibited high sensitivity and specificity at 93.5% and 80.6%, with PPV and NPV at 92.3% and 83.3%, respectively, and an accuracy of 89.8% (13). Kanumba et al (22) reported Alvarado score sensitivity, specificity, PPV, NPV, and accuracy of 94.1%, 90.4%, 95.2%, and 88.4%, respectively.

In a Moroccan stud, the sensitivity was 94.9%, the specificity was 72.7%, the positive predictive value was 98.4% and the negative predictive value was 44.4% (20). Additionally, the Alvarado score has been noted to overestimate the probability of appendicitis in females (23), and poorly identify complicated appendicitis in the elderly population (24).

However, in the Egyptian study reported much lower diagnostic value with an overall sensitivity of 68.9% (75% for male individuals and 58.8% for female individuals). Overall specificity was 40% (50% for male individuals and 33.3% for female individuals), PPV was 90.2%, and the negative predictive value was 11.1% (10). Furthermore, Al Awayshihet al. (12) reported a PPVof 89%. The sensitivity was 54% and specificity 75%. The authors concluded that Alvarado score is not a sensitive tool for aiding diagnosis of acute appendicitis.

The lower overall sensitivity of the score in females is expected. Premenopausal females have several gynecological conditions with presentations similar to appendicitis. The common misdiagnoses include pelvic inflammatory disease, gastroenteritis, urinary tract infection, ruptured ovarian follicle, and ectopic pregnancy. For their group of women with normal appendices who underwent an operation, alternative diagnoses included pelvic inflammatory disease, ruptured follicular cysts, twisted ovarian cysts, and ruptured ectopic pregnancy (25).

In the present study, US had a sensitivity, specificity, PPV, NPP and accuracy of 86.87%, 83.33%, 97.18%, 49% and 86.4%, respectively.

There is a notable variation in the sensitivity and specificity of abdominal US reported in the literature. For instance, Hosseini et al. (26) reported a sensitivity and specificity of 58% and 68%, respectively. Conversely, Abu-Yousef et al. (27) reported higher sensitivity (80%) and specificity (95%). A meta-analysis by Orr et al. (28) showed a sensitivity and specificity of 84.7% and 92.1%, respectively. The authors concluded that US should not be used to exclude appendicitis given the poor NPV. Conversely, a recent meta-analysis that included 21 studies reported a pooled sensitivity and specificity of 81% and 87%, respectively (29).

These findings, when taken together, might indicate methodological differences attributed to study settings and radiological expertise.

Study Limitations

This study has several limitations that should be acknowledged.

1. It was conducted at a single center, which may limit the generalizability of the findings to broader populations.
2. The reliance on intraoperative findings without histopathological confirmation in all cases may introduce variability in defining true appendicitis, especially in atypical presentations.

CONCLUSIONS

The Alvarado score can be used effectively in our setup to reduce the incidence of negative appendectomies. It helps to make prompt decision in suspected cases. However, the negative predictive value was low (45.72%) in the 5–7 score group, limiting its reliability in excluding appendicitis in this range. Alvarado score has better sensitivity, PPV, NPV and accuracy in males than females. Future research with larger and multicenter cohorts is recommended to validate findings and enhance diagnostic protocol

Authors' Contributions

Asawer Zain Al-Abideen Abdul-Razzaq: conceptualization; data curation; investigation; methodology; project administration; resources; software; writing – original draft and writing – review & editing

Alaa Jameel Hassan: conceptualization; data curation; investigation; methodology; project administration; writing – original draft and writing – review & editing.

Conflicts of Interest

The authors declare no conflict of interest regarding this article.

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Ethical Approval

The Medical Ethical Committee of The Department of surgery, College of Medicine, University of Thi-Qar approved this study (no. 15 on 8/10/2024).

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