

Evaluation of the Diagnostic Performance of Abdominal Ultrasonography in Acute Appendicitis: A Comparison with the Alvarado Clinical Score and Histopathological Findings

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Abstract:

Background and Objective: Acute appendicitis is one of the most common causes of acute abdomen, and accurate diagnosis plays a crucial role in reducing negative appendectomy rates and disease-related complications. This study aimed to compare the diagnostic performance of abdominal ultrasonography and the Alvarado scoring system with histopathological findings in patients suspected of having acute appendicitis.

Methods: In this cross-sectional study, 117 patients with suspected acute appendicitis who underwent appendectomy were enrolled. Demographic characteristics, clinical findings, laboratory results, ultrasonographic findings, and Alvarado scores were collected and compared with histopathological findings, which served as the reference standard.

Results: Of the 117 patients, 75 (64.1%) had histopathologically confirmed acute appendicitis, while 42 (35.9%) had negative appendectomy. Abdominal ultrasonography demonstrated a sensitivity of 40%, specificity of 69%, and an overall diagnostic accuracy of 50.4%. Both the mean white blood cell (WBC) count and the mean Alvarado score were significantly higher in patients with confirmed acute appendicitis than in those without appendicitis ($P < 0.05$).

Conclusion: Abdominal ultrasonography alone demonstrates insufficient sensitivity for the definitive diagnosis of acute appendicitis. However, combining ultrasonography with the Alvarado scoring system, clinical assessment, and laboratory findings significantly enhances diagnostic accuracy and facilitate more informed clinical decision-making.

Keywords: Appendicitis, Ultrasonography, Pathology, Appendectomy

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Background and Objective

Acute appendicitis is one of the most common causes of acute abdomen and a leading indication for emergency abdominal surgery. The lifetime incidence of appendicitis is estimated to be approximately 7–12%. Although it can occur at any age, it is most frequently observed in individuals between 10 and 19 years of age.¹ The incidence of acute appendicitis is higher in males than in females and is more prevalent in industrialized countries and certain populations.² Currently, there is no effective method for preventing acute appendicitis. Therefore, the only strategy to reduce its associated morbidity and mortality is early and timely diagnosis before the development of perforation or gangrene.³ However, the clinical manifestations of appendicitis overlap with those of several other abdominal conditions, making diagnosis particularly challenging, especially during the early stages of the disease.⁴ The overall rate of misdiagnosis of appendicitis has been reported to be approximately 15.3%, occurring significantly more frequently in women than in men. The rate of negative appendectomy reaches 23.2% among women of reproductive age and increases to nearly 30% in women aged 40–49 years. The highest rate of negative appendectomy has been reported in women older than 80 years.⁵ These findings indicate a substantial number of unnecessary surgical procedures. Conversely, even a slight delay in diagnosis is associated with an increased risk of appendiceal perforation. Over the past two decades, the rate of negative appendectomy has remained relatively stable with only a slight decline; however, since 2000, the incidence of perforated appendicitis appears to have increased.^{6,7} Accordingly, improving the preoperative diagnostic accuracy of acute appendicitis remains essential for reducing unnecessary appendectomies. The diagnosis of acute appendicitis is primarily clinical and is based on the patient's history and physical examination. In patients with atypical clinical presentations, laboratory investigations and imaging studies are often required to support the diagnosis.^{8,9}

Nevertheless, the diagnostic accuracy of clinical assessment alone is estimated to be no more than 80% under optimal circumstances.¹⁰ To improve diagnostic accuracy, several clinical scoring systems have been developed based on clinical and laboratory variables, among which the Alvarado scoring system is the most widely used.¹¹ Introduced in 1986, the Alvarado score incorporates clinical symptoms, physical signs, and laboratory findings into a 10-point scoring system. Based on the total score, patients are categorized as candidates for immediate surgery, observation, or discharge.¹² Among the available imaging modalities, ultrasonography is considered the first-line diagnostic tool for most patients with suspected acute appendicitis who present with equivocal clinical findings. Ultrasonography is non-invasive, widely available, and relatively inexpensive.¹³ However, its diagnostic performance is highly operator-dependent.¹⁴ Numerous studies have evaluated the role of ultrasonography in confirming or excluding acute appendicitis in patients with suspected disease.¹⁵ Despite advances in clinical assessment and imaging, histopathological examination of the resected appendix remains the gold standard for definitive diagnosis of appendiceal inflammation. Given that acute appendicitis is one of the most common surgical emergencies, accurate diagnosis is crucial to reducing disease-related morbidity and mortality. Therefore, identifying an effective preoperative diagnostic approach capable of narrowing the gap between clinical and pathological diagnosis remains an important clinical objective. Accordingly, the present study aimed to compare the diagnostic performance of abdominal ultrasonography and the Alvarado scoring system with histopathological findings in patients with acute appendicitis.

Materials and Methods

This cross-sectional study was conducted to evaluate and compare the diagnostic accuracy of abdominal ultrasonography and the Alvarado scoring system against

histopathological findings in the diagnosis of acute appendicitis. The study population consisted of all patients who presented to the emergency surgery department of Shahid Beheshti Hospital during 2018 with a preliminary diagnosis of acute appendicitis and subsequently underwent appendectomy. Participants were enrolled using a census sampling method, whereby all eligible patients presenting during the one-year study period were included. The minimum required sample size was calculated using a formula for diagnostic accuracy studies based on sensitivity and specificity. According to the study by Hosseini et al.,¹⁶ assuming a sensitivity of 71.3%, a specificity of 82.2%, and a prevalence of 50% for acute appendicitis, the minimum required sample size was estimated to be 81 patients. Due to the census sampling approach, all eligible patients presenting during the study period were enrolled, resulting in a final sample of 117 patients. Inclusion criteria comprised patients presenting with right lower quadrant (RLQ) abdominal pain suspicious for acute appendicitis who provided written informed consent to participate. Exclusion criteria included patients with abdominal pain outside the RLQ; those admitted for other medical conditions who subsequently developed RLQ pain during hospitalization; patients with a history of malignancy, immunodeficiency, or use of immunosuppressive medications; and patients whose symptoms resolved with non-operative management. Following approval of the study protocol and ethical approval from the Ethics Committee of Qom University of Medical Sciences (Ethics Code: IR.MUQ.REC.1399.169), and after obtaining the necessary administrative permissions from Shahid Beheshti Hospital, eligible patients were consecutively enrolled. Upon admission, demographic information, including age and sex, was recorded. Clinical history, physical examination findings, laboratory results, and the Alvarado score were documented for each patient using a standardized data collection checklist. In addition, all patients underwent preoperative abdominal ultrasonography, and findings were recorded according to the report of an

experienced radiologist. All patients with a preliminary diagnosis of acute appendicitis underwent appendectomy. The resected appendix specimens were subsequently submitted for histopathological examination, which served as the reference (gold standard) for the final diagnosis. Histopathological findings consistent with uncomplicated acute appendicitis, suppurative appendicitis, gangrenous appendicitis, or perforated appendicitis were classified as positive appendectomy. In contrast, specimens showing no evidence of appendiceal inflammation or only findings such as lymphoid hyperplasia or luminal obstruction without inflammation were considered negative appendectomy. For the final analysis, only patients who underwent appendectomy based on an initial diagnosis of acute appendicitis were included. Patients who underwent surgery primarily for other conditions and had incidental appendectomy performed during the same operation were excluded from the analysis.

Data were analyzed using IBM SPSS Statistics version 26 (IBM Corp., Armonk, NY, USA). Continuous variables are presented as mean $\pm$ standard deviation (SD), while categorical variables are expressed as frequencies and percentages. Differences in continuous variables between patients with and without histopathologically confirmed appendicitis were assessed using the independent-samples t-test. Associations between categorical variables and the final diagnosis of appendicitis were evaluated using the chi-square test.

The diagnostic performance of abdominal ultrasonography and the Alvarado scoring system was assessed by calculating sensitivity, specificity, and overall diagnostic accuracy, using histopathological findings as the reference standard. A two-sided p-value of less than 0.05 was considered statistically significant.

Findings

A total of 117 patients with suspected acute appendicitis who underwent appendectomy were included in this study. Of these, 70 patients (59.8%) were male, and 47 (40.2%) were female (Table 1).

Table 1. Demographic and Clinical Characteristics of the Study Population

Variable	Category	n (%)
Sex	Male	70 (59.8)
	Female	47 (40.2)
Migration of pain to the right lower quadrant (RLQ)	Yes	85 (72.6)
	No	32 (27.4)
Nausea and vomiting	Yes	81 (69.2)
	No	36 (30.8)
Fever	Yes	110 (94.0)
	No	7 (6.0)
Right lower quadrant (RLQ) tenderness	Yes	108 (92.3)
	No	9 (7.7)
Rebound tenderness	Yes	73 (62.4)
	No	44 (37.6)
Elevated white blood cell (WBC) count	Yes	88 (75.2)
	No	29 (24.8)
Anorexia	Yes	77 (65.8)
	No	40 (34.2)
Left shift of neutrophils	Yes	68 (58.1)
	No	49 (41.9)

The mean age of the patients was 23.13 ± 9.74 years, with an age range of 5 to 75 years. Histopathological examination confirmed acute appendicitis (positive appendectomy) in 75 patients (64.1%), while 42 patients (35.9%) showed no pathological evidence of appendicitis (negative appendectomy) (Table 1). Abdominal ultrasonography revealed positive findings suggestive of acute appendicitis in 43 patients (36.8%) and negative findings in 74 patients (63.2%). Comparison of ultrasonographic findings with histopathological results demonstrated that abdominal ultrasonography had a sensitivity of 40%, specificity of 69%, and an overall diagnostic accuracy of 50.4% for diagnosing acute appendicitis (Table 2).

Table 4. Diagnostic Performance of the Alvarado Score in the Diagnosis of Acute Appendicitis

Alvarado Score / Outcome	Positive Appendicitis	Negative Appendicitis	Total	P value
Alvarado score < 7	24	31	55	< 0.001
Alvarado score $\geq$ 7	51	11	62	
Total	75	42	117	
Mean Alvarado score (Mean $\pm$ SD)	7.2 ± 1.9	4.8 ± 1.7	—	—

Table 2. Comparison of Abdominal Ultrasonography Findings with Histopathological Diagnosis of Acute Appendicitis

Abdominal Ultrasonography	Positive Appendicitis	Negative Appendicitis	Total
Positive	30	13	43
Negative	45	29	74
Total	75	42	117

Comparison of continuous variables between patients with and without histopathologically confirmed acute appendicitis showed that the mean age did not differ significantly between the two groups ($P = 0.186$). In contrast, the mean white blood cell (WBC) count was significantly higher in patients with acute appendicitis than in those without appendicitis ($P = 0.004$) (Table 3).

Table 3. Comparison of Continuous Variables Between Patients with and without Histopathologically Confirmed Acute Appendicitis

Variable	Negative Appendicitis	Positive Appendicitis	P value
Age (years)	26.2 ± 14.7	22.7 ± 13.09	0.186
White blood cell	$11,347 \pm 4,215$	$13,993 \pm 4,529$	0.004

The mean Alvarado score was significantly higher in patients with histopathologically confirmed acute appendicitis than in those without appendicitis ($P < 0.001$) (Table 4).

Discussion and Conclusion

The present study was conducted to evaluate the diagnostic value of abdominal ultrasonography in patients with suspected acute appendicitis by comparing ultrasonographic findings with histopathological results obtained following appendectomy.

In addition, the associations between selected clinical and laboratory parameters and the final pathological diagnosis of acute appendicitis were investigated. In the present study, abdominal ultrasonography demonstrated a sensitivity of 40%, a specificity of 69%, and an overall diagnostic accuracy of 50.4% for diagnosing acute appendicitis. These findings indicate relatively low sensitivity and moderate specificity. Compared to most previously published studies, the diagnostic performance observed in our study was considerably lower, suggesting that ultrasonography alone may have limited diagnostic utility in our population. Mohamed Hussein Hesham et al. reported that both abdominal ultrasonography and the Alvarado scoring system exhibited high diagnostic performance in the evaluation of acute appendicitis. In their study, ultrasonography achieved a sensitivity of 98.46% and a specificity of 93.82%, substantially higher than the corresponding values observed in our study.¹⁷ These findings suggest that high-quality ultrasonography, particularly when combined with clinical scoring systems, can significantly improve diagnostic accuracy. Similarly, Ahmad et al. demonstrated that the combined use of the Alvarado score and abdominal ultrasonography yielded a sensitivity of 96.3%, a specificity of 90%, and an overall diagnostic accuracy of 89%, markedly outperforming the diagnostic performance of ultrasonography alone observed in the present study.¹⁸ These results support the concept that combining clinical assessment with imaging modalities provides greater diagnostic reliability than relying solely on ultrasonography. Another study reported that abdominal ultrasonography achieved a sensitivity of approximately 71.2% and a specificity of 83.3% in diagnosing acute appendicitis.¹⁹ Although these values remain lower than those reported in some other investigations, they are still substantially higher than the sensitivity observed in our study, while the specificity was relatively comparable. These discrepancies may be attributed to differences in operator experience, imaging protocols, diagnostic criteria for positive ultrasonographic findings, and variations in study populations. Since abdominal ultrasonography is well recognized as an operator-dependent imaging

modality, differences in examiner expertise may significantly influence its diagnostic performance. A comprehensive study comparing the Alvarado score, abdominal ultrasonography, and C-reactive protein (CRP) demonstrated that combining these diagnostic tools increased sensitivity to more than 94%, although specificity decreased to some extent.²⁰ These findings further emphasize that a multimodal diagnostic strategy is superior to the use of any single diagnostic modality for evaluating suspected acute appendicitis. Previous studies have also reported considerable variability in the diagnostic performance of abdominal ultrasonography. Reported sensitivity values range from approximately 62%, with specificity approaching 80%, indicating substantial heterogeneity across different clinical settings.²¹ Collectively, these findings, together with those of the present study, suggest that abdominal ultrasonography alone may not provide sufficient sensitivity to reliably confirm or exclude acute appendicitis. Therefore, ultrasonography should be interpreted in conjunction with validated clinical scoring systems, such as the Alvarado score, as well as laboratory markers, to improve overall diagnostic accuracy. This conclusion is consistent with current evidence supporting the development and implementation of multimodal diagnostic algorithms for patients with suspected acute appendicitis.

Conclusion

The findings of the present study indicate that abdominal ultrasonography, when used as a standalone diagnostic modality, provides moderate specificity but insufficient sensitivity for the definitive diagnosis of acute appendicitis. Consequently, reliance on ultrasonography alone may result in missed cases of true appendicitis. In contrast, elevated WBC counts and higher Alvarado scores were significantly associated with histopathologically confirmed acute appendicitis and may serve as valuable adjunctive tools in clinical decision-making. Overall, integrating clinical assessment, laboratory findings, and imaging modalities is likely to improve diagnostic accuracy and optimize the management of patients with suspected acute appendicitis.

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