



Diagnostic performance of physical examination and radiologic modality for identifying acute appendicitis; a diagnostic cross-sectional study

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Abstract

Introduction: Acute appendicitis remains one of the most common causes of acute abdominal pain requiring urgent evaluation, and timely diagnosis is essential to prevent complications. Clinical assessment and imaging are routinely used to support diagnostic decision-making, yet their accuracy varies by settings and patient population.

Objectives: This study aimed to evaluate the diagnostic performance of physical examination and sonographic assessment in identifying acute appendicitis using pathology as the reference standard.

Patients and Methods: The study used a cross-sectional diagnostic design and included 190 patients with suspected appendicitis who presented to Shahid Mohammadi hospital between March 2021 and March 2025. Demographic characteristics, sonographic findings, physical examination results, and pathology reports were retrospectively extracted from hospital clinical archives. Agreement between each diagnostic modality and pathology was evaluated using Cohen's kappa coefficient, and diagnostic performance, including accuracy, sensitivity, specificity, positive and negative predictive values (PPV and NPV), and likelihood ratios, was calculated for both sonography and physical

Results: The agreement analysis of 190 suspected appendicitis cases showed that both modalities demonstrated significant concordance with pathology, with sonography achieving a Cohen's kappa of 0.726 and physical examination showing an even stronger agreement at 0.821. Using pathology as the diagnostic reference standard, sonography achieved an accuracy of 86.31%, sensitivity of 87.4%, specificity of 85.3%, a PPV of 85.6%, and a NPV of 14.4%. In comparison, physical examination demonstrated superior diagnostic performance, with 91% accuracy, 90.5% sensitivity, 91.6% specificity, a PPV of 91.5%, and a NPV of 90.6%.

Conclusion: Both sonography and physical examination demonstrated meaningful diagnostic value when assessed against pathology as the reference standard, supporting their utility as reliable clinical tools for identifying suspected appendicitis.

Introduction

Acute appendicitis is one of the most common causes of acute abdominal pain requiring emergency surgery, and timely diagnosis is essential to prevent perforation, sepsis, and unnecessary negative appendectomy (1-3). In the United States, an estimated 300,000 hospital visits each year are attributed to appendicitis (4). Stump appendicitis, an acute inflammation of the remaining appendiceal tissue, is an uncommon postoperative complication, occurring in approximately 1 out of every 50,000 appendectomy cases (1). Despite its frequency, the clinical presentation can be variable, especially in children, older adults, and pregnant patients, which complicates early recognition (5,6). Classical right lower quadrant tenderness, migration of pain, and systemic inflammatory response are

helpful but not pathognomonic, and overlap with many other abdominal conditions (6,7). Consequently, clinicians rely on a combination of history, physical examination, laboratory tests, and increasingly, imaging and clinical scoring systems to stratify risk and guide management.

Physical examination remains the cornerstone of initial assessment, and several studies have evaluated its diagnostic accuracy compared with imaging-based strategies (8-10). In a large clinical series, diagnosis based on history, physical examination, and laboratory testing alone achieved an overall accuracy of 84% in patients with right lower quadrant pain, highlighting the continuing value of careful bedside assessment (11). However, the specificity of physical examination is often limited, particularly in atypical presentations and in patients with

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Key point

In a cohort study of 190 suspected appendicitis cases, pathology served as the diagnostic reference standard. Sonography demonstrated moderate performance with 86.31% accuracy, 87.4% sensitivity, 85.3% specificity, a positive predictive value (PPV) of 85.6%, and a negative predictive value (NPV) of 14.4%. In contrast, physical examination showed stronger diagnostic value overall, achieving 91% accuracy, 90.5% sensitivity, 91.6% specificity, a PPV of 91.5%, and an NPV of 90.6%.

obesity, leading to higher negative appendectomy rates when surgery is based solely on clinical findings (12). This diagnostic uncertainty has driven the integration of radiologic modalities into routine practice as adjuncts to, rather than replacements for, clinical examination.

Radiologic imaging, particularly ultrasonography, computed tomography (CT), and magnetic resonance imaging (MRI), has markedly improved diagnostic performance in suspected appendicitis (10,13-15). In a large clinical study, ultrasonography and CT both showed high sensitivity and specificity, with CT generally outperforming ultrasound and yielding lower negative appendectomy rates compared with reliance on physical examination alone (11). Other series and meta-analyses similarly report sensitivities of approximately 65–92% for ultrasound and over 90% for CT, reinforcing their role in contemporary diagnostic pathways (7). Magnetic resonance imaging has emerged as a radiation-free alternative with excellent accuracy, particularly in children and young adults (14). Nevertheless, the relative contributions and combined performance of physical examination and different imaging modalities in real-world settings remain heterogeneous, and optimal diagnostic algorithms continue to be debated. The present diagnostic cross-sectional study aims to evaluate the diagnostic performance of physical examination and radiologic modalities for identifying acute appendicitis in routine practice.

Objectives

The objective of this study was to comprehensively evaluate the diagnostic performance of physical examination and sonographic assessment in identifying acute appendicitis using pathology as the definitive reference standard, by determining the degree of agreement between each modality and pathology, quantifying their diagnostic accuracy through key performance indicators, and assessing their clinical utility in routine decision-making for patients presenting with suspected appendicitis.

Patients and Methods

Study design and participants

This cross-sectional diagnostic study was conducted on 190 patients presenting with suspected appendicitis who were referred to Shahid Mohammadi Hospital in Bandar Abbas between March 2021 and March 2025. The sampling

method was simple randomized sampling. Individuals who were evaluated during this period and met the study eligibility criteria were considered for inclusion.

Inclusion and exclusion criteria

The study included all patients presenting with suspected appendicitis who had complete demographic information (age and gender) and documented sonographic findings, physical examination results, and corresponding pathology reports used as the diagnostic reference standard. Patients were excluded if their medical records were incomplete, missing any of the required clinical or diagnostic data, or if documentation was insufficient to confirm the final pathology outcome.

Data collection

Demographic and clinical information for all eligible patients was retrospectively extracted from the clinical document archive of Shahid Mohammadi hospital. Collected data included patient demographic characteristics (age and gender), sonographic findings, physical examination results, and corresponding pathology reports used as the diagnostic reference standard for appendicitis. All records were systematically reviewed to ensure completeness, accuracy, and consistency prior to analysis.

Outcome measurement

The primary outcome was the level of agreement between each diagnostic modality and pathology, quantified using Cohen's kappa coefficient to determine the degree of concordance. The secondary outcome was the diagnostic performance of sonography and physical examination, assessed through accuracy, sensitivity, specificity, positive and negative predictive values (PPV and NPV), and positive and negative likelihood ratios (LR⁺ and LR⁻), using pathology results as the reference standard.

Statistical analysis

All statistical analyses were conducted using SPSS software version 27 (IBM Corp., USA). Agreement between each diagnostic modality and the pathology used as the reference standard was assessed using Cohen's kappa coefficient, with values greater than 0.60 interpreted as indicating substantial agreement. Diagnostic performance metrics, including accuracy, sensitivity, specificity, PPV, and NPV, were calculated for both sonography and physical examination. Likelihood ratios were also computed, with LR⁺ values exceeding 10 and LR⁻ values below 0.1 considered strong indicators of diagnostic strength. Statistical significance was defined as $P < 0.05$ for all analyses.

Results

The study population consisted of 190 suspected appendicitis patients with a mean age of 49.45 ± 18.73

years, with men forming a slightly larger proportion. Sonographic evaluation showed a nearly even split between positive and negative findings for appendicitis, nearly mirrored by the distribution observed in physical examination results. Meanwhile, pathology, used as the reference standard, also demonstrated an equal division between confirmed and non-confirmed appendicitis cases (Table 1).

The agreement analysis showed that sonography identified most pathology-confirmed appendicitis cases as positive, while a smaller proportion of negative pathology cases were incorrectly classified as positive; conversely, most pathology-negative cases were correctly identified as negative by sonography. Physical examination demonstrated an even stronger alignment with pathology, with the majority of true appendicitis cases classified as positive and most non-appendicitis cases classified as negative. Agreement statistics indicated substantial concordance for sonography and an even higher level of agreement for physical examination, with both modalities showing statistically significant kappa values (Table 2).

The diagnostic value performance indicated that the sonography showed moderate diagnostic performance, with 86.31% accuracy, 87.4% sensitivity, and 85.3% specificity, while physical examination performed better overall, reaching 91% accuracy, 90.5% sensitivity, and 91.6% specificity (Table 3).

Table 1. Baseline characteristics and clinical findings of included patients

Variable		Frequency	Percent
Gender	Male	106	55.8
	Female	84	44.2
Appendicitis diagnosis by sonography	Positive	97	51.1
	Negative	93	48.9
Appendicitis diagnosis by physical examination	Positive	94	49.5
	Negative	96	50.5
Appendicitis diagnosis by pathology results	Positive	95	50
	Negative	95	50
Age (year), mean $\pm$ SD		49.45 $\pm$ 18.73	

SD: Standard deviation.

Discussion

The present study evaluated physical examination and sonography compared to pathology as the reference standard, showing that both modalities had meaningful diagnostic value in patients with suspected appendicitis. This overall pattern is consistent with prior literature indicating that clinical assessment and ultrasound are useful components of appendicitis workup, although neither approach is perfectly definitive on its own. The finding that physical examination retained diagnostic value is in line with earlier studies showing that bedside clinical assessment contributes substantially to decision-making in appendicitis, especially when interpreted alongside the broader clinical picture. Published evidence has suggested that physical examination can be highly sensitive in some settings but less specific than imaging, reflecting the fact that abdominal tenderness and other examination findings are clinically important yet not unique to appendicitis (7,10). The systematic review and meta-analysis by Benabbas et al synthesized evidence from 21 studies involving 8,605 pediatric patients, providing a comprehensive evaluation of bedside diagnostic tools for suspected appendicitis in the emergency department. Their findings highlight that elements of the physical examination demonstrated the strongest association with confirmed appendicitis, outperforming historical features, routine laboratory markers, and point-of-care ultrasound when considered individually (7). Park et al evaluated 2,763 patients using pathology as the diagnostic reference standard and reported that physical examination demonstrated very high diagnostic performance, with a sensitivity of 99.0%, specificity of 76.1%, a PPV of 88.1%, and a NPV of 97.6%; the study findings emphasize that bedside clinical assessment remains a highly reliable tool for identifying acute appendicitis (10). Therefore, the present results support the continued role of physical examination as an initial diagnostic step rather than a standalone confirmatory test.

Sonography also showed useful diagnostic performance in the current study, which aligns with the broader literature supporting ultrasound as a practical and accessible

Table 2. Evaluating the agreement between the sonographic findings and physical examination with pathology results as diagnostic standard references in the diagnosis of appendicitis

Diagnostic modality	Pathology results (Standard reference)			Kappa	P value
	Positive (n = 95)	Negative (n = 95)	Total		
Sonographic					
Positive, N (%)	83 (87.4)	14 (14.7)	N = 97	0.726	<0.001*
	83 (85.6)	14 (14.4)			
Negative, N (%)	12 (12.6)	81 (85.3)	N = 93		
	12 (12.9)	81 (87.1)			
Physical examination					
Positive, N (%)	86 (90.5)	8 (8.4)	N = 94	0.821	<0.001*
	86 (91.5)	8 (8.5)			
Negative, N (%)	9 (9.5)	87 (91.6)	N = 96		
	9 (9.4)	87 (90.6)			

N: Number, *Cohen's kappa coefficient.

Table 3. Performance diagnostic value of sonographic findings and physical examination compared to pathology results as diagnostic standard references for appendicitis diagnosis

Parameters	Diagnostic method	
	Sonographic	Physical examination
Accuracy (%)	86.31	91
Sensitivity (%)	87.4	90.5
Specificity (%)	85.3	91.6
PPV (%)	85.6	91.5
NPV (%)	87.1	90.6
False positive (%)	14.4	8.4
False negative (%)	12.6	9.5
LR ⁺	5.94	10.77
LR ⁻	0.15	0.10
DOR	39.6	107.7

PPV: Positive predictive value, NPV: Negative predictive value, LR⁺: Positive likelihood ratios, LR⁻: Negative likelihood ratios, DOR: Diagnostic odds ratio.

imaging tool in suspected appendicitis. Previous systematic reviews and observational studies have reported variable but generally favorable performance for ultrasound, with diagnostic accuracy influenced by operator experience, patient factors, and study setting. A cross-sectional study reported that ultrasonography showed excellent diagnostic performance in their cohort of 2,763 patients, with a sensitivity of 99.1%, specificity of 91.7%, a PPV of 96.5%, and a NPV of 97.7% (10). Accordingly, Roberts et al, in an assessment of a total of 8555 ultrasound examinations, concluded that ultrasound offers gold-standard diagnostic accuracy for appendicitis and contributes to lowering the rate of unnecessary appendectomies (16). Moreover, Mostbeck et al emphasized that ultrasound should serve as the first-line imaging modality for suspected acute appendicitis, noting that graded-compression ultrasonography provides excellent specificity in both pediatric and adult populations (17). Recently, Ma et al in a study in China reported that ultrasound is used more frequently than CT for evaluating suspected appendicitis in both adults and children, and that its diagnostic performance is comparable to CT, supporting its role as a reliable first-line imaging option (18). The present findings are therefore consistent with the idea that sonography can provide clinically meaningful support for diagnosis when pathology is used as the reference standard, particularly in settings where rapid, radiation-free imaging is preferred.

The comparative performance of physical examination and sonography in this study suggests that both approaches remain relevant in routine practice and may be complementary rather than competing tools. This interpretation is consistent with prior reports showing that diagnostic strategies for appendicitis often achieve the best balance when clinical findings are integrated with imaging rather than relying on a single test alone (7,10,17). In practical terms, the present results reinforce the value of combining bedside assessment with sonographic

evaluation when appendicitis is suspected, while keeping pathology as the definitive standard for confirmation.

Several factors may help explain why diagnostic performance varies across studies, including differences in patient populations, disease severity, operator expertise, and local diagnostic pathways. The present study was conducted in a single hospital setting over a defined period, which may influence how the results compare with those from larger multicenter cohorts or systematic reviews. Even so, the findings add support to the broader body of evidence that both clinical examination and ultrasound have a meaningful role in the diagnostic workup of appendicitis. Collectively, this study indicates that both physical examination and sonography provide useful diagnostic information for identifying acute appendicitis when compared with pathology. The results support their continued use as practical clinical tools in the evaluation of suspected appendicitis, particularly when interpreted together within the full clinical context.

Conclusion

When evaluated against pathology as the diagnostic reference standard, both sonography and physical examination demonstrated meaningful diagnostic utility in identifying appendicitis. Sonography showed solid performance across accuracy, sensitivity, specificity, and predictive values, indicating its usefulness as a non-invasive diagnostic tool. Physical examination likewise exhibited strong alignment with pathology findings, reinforcing its continued relevance in clinical assessment. Together, these results highlight that each modality provides valuable diagnostic information when interpreted in relation to definitive pathological outcomes.

Limitations of the study

The retrospective nature of data extraction from clinical archives introduces the possibility of documentation variability or missing contextual clinical information that could not be verified. Additionally, the study relied solely on recorded sonographic and physical examination findings without the ability to standardize examiner technique or operator experience, which may have influenced diagnostic performance. Finally, although pathology served as the reference standard, the cross-sectional design did not allow assessment of temporal factors or clinical progression that might affect diagnostic accuracy.

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Authors' contribution

Conceptualization: Morteza Ahmadi Nasab and Mohamadnavid Vanda.

Data curation: Morteza Ahmadi Nasab and Mohamadnavid Vanda.

Formal analysis: Ali Hadavand Khani.

Investigation: Morteza Ahmadi Nasab and Ali Hadavand Khani.

Methodology: Ali Hadavand Khani.

Project management: Mohamadnavid Vanda.

Resources: All authors.

Supervision: All authors.

Validation: Ali Hadavand Khani.

Writing—original draft: All authors.

Writing—review and editing: All authors.

Conflicts of interest

The authors declare no conflict of interest.

Data availability statement

The datasets generated during and/or analyzed during the current study are available from the corresponding author on reasonable request.

Declaration of generative artificial intelligence (AI) and AI-assisted technologies in the writing process

While preparing this work, the authors utilized AI ([Grammarly](#), [Perplexity](#), and [Copilot](#)) to refine grammar points and language style. Subsequently, they thoroughly reviewed and edited the content as necessary, assuming full responsibility for the publication's content.

Ethical issues

This study was conducted at Shahid Mohammadi Hospital in Bandar Abbas in accordance with the Declaration of Helsinki. It was derived from the thesis work of general surgery student Mohamadnavid Vanda (Thesis No. 4030536) and was approved by the Ethics Committee of the School of Medicine, Hormozgan University of Medical Sciences, Bandar Abbas, Iran (Ethical Code: IR.HUMS.REC.1404.002; <https://ethics.research.ac.ir/form/n21givsufbz1qoy.pdf>). The authors also adhered to all relevant ethical standards, including the avoidance of plagiarism, data fabrication, and duplicate publication.

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