

DIAGNOSTIC ACCURACY OF ABDOMINAL ULTRASOUND IN INFLAMED ACUTE APPENDICITIS: A SYSTEMATIC REVIEW

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Abstract

Background: Acute appendicitis is the most common condition that presents with an acute abdomen needing emergency surgery. The reported proportion of missed diagnoses of appendicitis ranges between 20% and 40%. A delay or misdiagnosis of appendicitis can result in severe complications such as perforation, abscess formation, sepsis, and intra-abdominal adhesions. The aim of this study is to assess the diagnostic accuracy of abdominal ultrasound in inflamed acute appendicitis.

Methods: For this systematic review, publications that were published from 2015 to 2024 were taken into account during the search process. This was achieved through the utilization of numerous online reference sources, such as SagePub, Research Gate and google scholar. The decision was made to exclude review articles, previously published works, and incomplete works.

Results: A total of 11,700 articles were retrieved from database searches. After removing 2,500 duplicates, 9,200 articles proceeded to screening. During the title and abstract review, 8,800 were excluded for not meeting inclusion criteria, leaving 400 for full-text assessment. After a detailed review, 390 were excluded due to issues like insufficient data, poor methodology, or lack of relevance. Ultimately, 10 high-quality studies were selected for the systematic review.

Conclusion: This systematic review demonstrates the accuracy of sonography in diagnosing inflamed acute appendicitis. An ultrasound examination can be carried out quickly and with sufficient accuracy to determine whether a person can be diagnosed as a patient with appendicitis.

INTRODUCTION

The normal appendix is a peristaltic tubular structure with a blind end. Its wall is less than 3 mm thick and its maximum transverse diameter is less than 6 mm. Its average length is 8–10 cm, but there are long forms that measure up to 35 cm [20, 32]. The appendix is a small vestigial organ located

distally to the ileocecal valve. Also referred to as the "Vermiform appendix," this structure was first described in the 16th century by the Italian anatomist, Berengario de Capri². Appendicitis is the most common infectious disease in the abdomen³. Lifetime risk is 8.6% in men and 6.7% in

women⁴. Appendicitis is the most common cause of an acute abdomen. However, the diagnosis can be challenging because a missed appendicitis represents the third largest number of malpractice claims for emergency physicians⁵. Although acute appendicitis (AA) is one of the most common challenging surgical diseases, it has been considered uncommon among African populations in Africa and in the developing world. But in the last few decades, despite a paucity of data, some authors have reported an increasing incidence of AA in Africa. In addition, the high rate of advanced appendicitis (ie, free perforations, abscesses) in Africa, 40%-50% vs. 20% in industrialized countries, illustrates the impact of a delayed presentation. The mortality rates for appendicitis in African series vary from 0.9% to 4% vs. 0.5% in Western countries⁶.

Appendicitis represents one of the most common causes of abdominal pain of adult patients referred to the emergency department. More than 250,000 cases of appendicitis are diagnosed in the United States each year, and appendectomy is the most frequent emergent surgery performed worldwide⁷. AA has 7.0% prevalence, and its incidence peaks between the ages of 10 and 30⁸. Classic symptoms of appendicitis include vague periumbilical pain, anorexia/ nausea/ intermittent vomiting, migration of pain to the right lower quadrant, and low-grade fever⁹. First described by Fitz in 1886, it is characterized by inflammation of the vermiform appendix. Treves is credited as the first to treat AA in 1902. AA occurs when there is obstruction of the appendiceal orifice (such as lymphoid hyperplasia or fecaliths), resulting in inflammation. This causes progressive distension of the appendix, eventually leading to vascular compromise, allowing the growth of pathogenic microorganisms¹⁰. Atypical presentations are commonly misdiagnosed, resulting in increased morbidity, mortality and potential litigation. Emergency ultrasound (EUS) continues to develop and is now a core technique in emergency medicine (EM). Currently, there are 11 core EUS applications, and each application is covered in the literature. The six initially established applications are: Focused assessment with sonography for trauma (FAST) examination, abdominal aortic aneurysm, emergency echocardiography, pregnancy, hepatobiliary ultrasound, and renal ultrasound. The

five recently added applications are: Deep venous thrombosis, thoracic ultrasound, musculoskeletal ultrasound, ocular ultrasound, and procedural ultrasound¹¹. A rapid and accurate diagnosis of appendicitis is particularly critical in pregnant patients because non-perforated appendicitis can quickly progress to appendiceal rupture, which is associated with high rates of early delivery, miscarriage, and fetal loss¹². Appendicitis is the most common acute abdominal disorder that requires surgery.¹⁻² The diagnosis is commonly made on the grounds of a combination of history, physical examination, laboratory tests, and diagnostic imaging findings. As these diagnostic steps often take place in a serial fashion in the emergency department (ED), patients suspected of appendicitis tend to stay for prolonged periods of time, requiring considerable staff and physical resources¹³. Delayed diagnosis may lead to necrosis and perforation of inflamed appendix lumen leading to increased mortality and morbidity. Although with significant improvements in quality and availability of imaging techniques, accurate diagnosis of acute appendicitis has increased in recent years but negative appendectomy still remains a concern, with a rate of 3.7-13.5 % in children and about 12 % in adults, imposing additional risks and costs both to patients and health system¹⁴. Acute appendicitis is one of the most common surgical emergencies presented to the Accident and Emergency Departments in which the surgeon has to take a quick decision about its operative management. The lifetime prevalence of acute appendicitis is about 22% ranging between 13-77%.¹⁵ A major issue experienced by clinicians is a deficiency of clear evidence-based guidelines or consensus as to the indications for a particular diagnostic modality, leaving the discretion to healthcare systems and even specific institutions to implement their preferred approach. No universally recognized diagnostic imaging algorithm exists for appendicitis¹⁶. Laparotomy is the gold standard tool in diagnosis and treatment of appendicitis, but is invasive and has its own limitations and dangers. This has led the researchers to evaluate the diagnostic accuracy of other diagnostic tools such as ultrasonography in detection of appendicitis¹⁷. Ultrasonography is a useful noninvasive means of determining a diagnosis of acute appendicitis at the

bedside in the emergency department (ED). As concerns about exposure to radiation have increased, the accuracy of ultrasonography has improved substantially with no harmful radiation, which is especially important in pediatric patients and reproductive women¹⁸. Interpretation of acquired point-of-care ultrasound images is significantly more accurate when performed by physicians with prior emergency ultrasound fellowship training and familiarity with the typical sonographic appearance of small bowel obstruction¹⁹. Point-of-care ultrasound (POCUS) is as accurate as radiology-performed ultrasound in evaluating children with clinical concern for appendicitis²⁰. Point-of-care ultrasonography (POCUS) has proven to be a valuable diagnostic tool in diagnosing AA and has a positive impact on clinical decision-making. Overall sensitivity and specificity of US is 76% and 95% respectively²¹.

METHOD AND MATERIAL

This systematic review follows the PRISMA (Preferred Reporting Items for Systematic Reviews and Meta-Analyses) guidelines but does not include a meta-analysis. A comprehensive literature search was conducted between time period of (year 2015 - 2025) including are PubMed, Scopus, Web of science and google scholar etc. Terms included combinations of keywords and Medical Subject Headings (MeSH) such as: Inflamed Acute Appendicitis, ultrasound, sonography USG, Diagnosis, Assessment, Detection.

The study aims is to evaluate the diagnostic accuracy of inflamed acute appendicitis.

Inclusion and Exclusion criteria

Right lower quadrant pain, Fever, Nausea/Vomiting, Migratory pain, Clinical suspicion of appendicitis based on history and physical exam, and elevated white blood cell count. Exclusion criteria: Pregnancy, Recent abdominal surgery, known inflammatory bowel disease, Signs of advanced peritonitis.

Assessment of the methodological quality

Information on the total number of enrolled patients, first author, journal name, year of publication, sample size, mean age, study design, clinician who performed the ultrasound, and primary data outcomes, including true positives, false positives, true negatives, and false negatives, extracted from all included studies are shown table 1 and 2.

RESULT

A total of 11,700 articles were retrieved from database searches. After removing 2,500 duplicates, 9,200 articles proceeded to screening phase. During the title and abstract review, 8,800 were excluded for not meeting inclusion criteria, leaving 400 for full-text assessment. After a detailed review, 390 were excluded due to issues like insufficient data, poor methodology, or lack of relevance. Ultimately, 10 high-quality studies were selected for the systematic review.

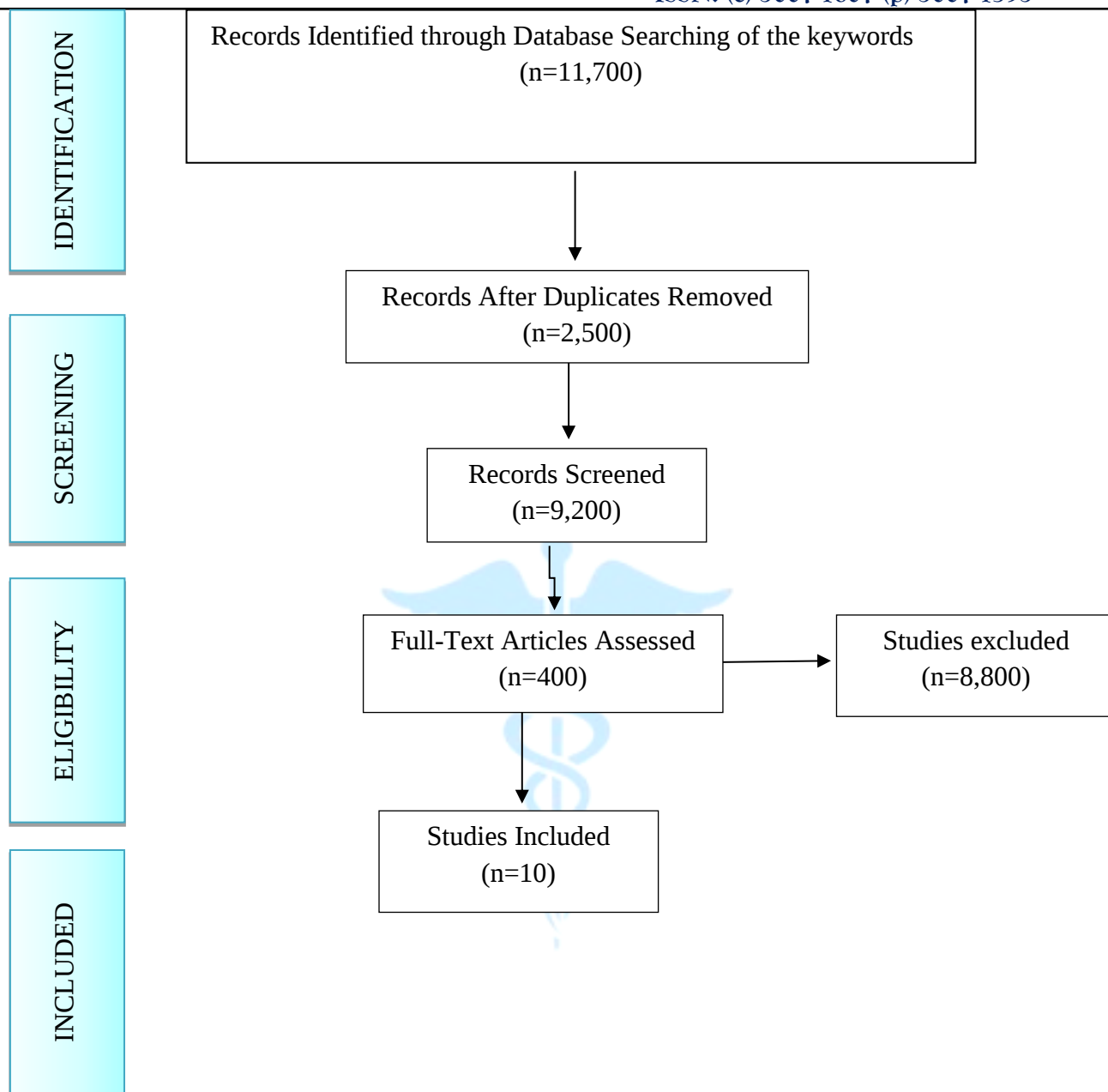


Figure 1: PRISMA flow diagram

Table 1:

Authors	Year	Journal	Sample size	Mean age	Study design	Operator	DUS
E Arruzza et al ¹⁶	2022	Journal of radiography	A total of 15 patients were included in this study	Not mentioned	Prospective and retrospective studies	Radiologist	Sonographically confirmed Acute appendicitis
Backer ¹⁹	2021	Acade Emerg Med	A total of 19 patients were included in this study	19	prospective	EM physician	Sonographically confirmed Acute appendicitis
Doniger ²⁰	2018	Pediatric Emergency Care	A total of 40 patients were included in this study	9.3	prospective	EM residents	sonographically confirmed Acute appendicitis
Sharif ⁵	2018	CJEM	A total of 19 patients were included in this study	Not mentioned	Retrospective	EM Physician or residents	sonographically confirmed Acute appendicitis
Kim ¹⁸	2015	Hong Kong journal of Emergency department	A total of 166 patients were included in this study	10.6	Retrospective	EM Physician or residents	Sonographically confirmed Acute appendicitis
Fathi ¹⁴	2015	J Ultrasound	A total of 97 patients were included in this study	34.35	prospective	EM Physician or residents	Sonographically confirmed Acute appendicitis
Topin ⁶	2016	The journal of Emergency department	A total of 100 patients were included in this study	33.2	prospective	EM Physician	Sonographically confirmed Acute appendicitis
Unluer ¹¹	2016	World J Emerg Med	A total of 100 patients were included in this study	32.9	prospective	EM Physician	Sonographically confirmed Acute appendicitis
Gungor ⁸	2017	Acad Emerg Med	A total of 264 patients were included in this study	30.0	prospective	EM Physician	Sonographically confirmed Acute appendicitis
Karimi ¹⁷	2017	Emergency	A total of 108 patients were included in this study	23.9	prospective	EM Physician	Sonographically confirmed Acute appendicitis

Table 2:

Authors	Sensitivity %	Specificity %	True Positive %	False Positive %	False Negative %	True Negative %	Positive Predictive Value %	Negative Predictive Value %
E Arruzza et al ¹⁶	95	95	468	61	102	369	73	85.5
Backer et al ¹⁹	85	63	61	68	11	116	47	91.3
Doniger et al ²⁰	94	88	15	3	1	21	83	95.5
Sharif et al ⁵	69	91	18	6	8	58	75	87.9
Kim et al ¹⁸	100	100	40	NA	NA	126	100	100
Fathi et al ¹⁴	44	85	19	8	24	46	70	65.7
Topin et al ⁶	88	96	22	3	3	72	88	96
Unluer et al ¹¹	74	67	34	18	12	36	65	75
Gungor et al ⁸	92	96	156	4	13	91	98	87.8
Karimi et al ¹⁷	80	83	27	12	10	59	69	85.5

DISCUSSION

Acute appendicitis is one of the leading abdominal emergencies worldwide⁴. It is difficult for emergency physicians to diagnosis acute appendicitis because diagnosis based on clinical evaluation alone has a sensitivity of 39% to 74% and a specificity of 57% to 84%²². AA is one of the most common surgical emergencies globally. AA has a lifetime incidence of 8.6% in men and 6.7% in women, with a peak incidence between the second and third decade of life. The classic presentation of AA is characterised by migratory abdominal pain to the right iliac fossa, associated with localized peritonism. The classical presentation has been estimated to occur in between 50 to 60% of patients, with atypical presentations occurring commonly due to a retrocaecal location of the appendix, or due to patient factors such as pregnancy or obesity. Appendectomy following clinical diagnosis is associated with a 20% negative appendectomy rate. While prompt diagnosis and management of AA is important to reduce the morbidity associated with perforated appendicitis, negative appendectomy has been associated with similar morbidity as compared to appendectomy in patients with uncomplicated AA . Given the morbidity associated with negative appendectomy, imaging modalities should be considered to increase the diagnostic accuracy in patient presenting with suspected AA²³. Notably, some patients diagnosed with acute appendicitis show complete and definitive healing with antibiotic treatment alone. In contrast, others temporarily improve. However, the disease worsens after treatment, progressing to complicated acute appendicitis²⁴. The “uncomplicated” appendicitis comes with a dilemma. Differentiating the treatment for uncomplicated and complicated appendicitis also implies the need to safely differentiate the two before treatment can be started.²⁵ Mattei et al. concluded that “acute appendicitis can resolve spontaneously and recur repeatedly in the same individual,” and that in many cases of chronic or recurrent appendicitis, “they can be avoided by the accurate diagnosis and operative management of acute appendicitis” at initial presentation. Several subsequent reports concur with this conclusion and agree that the primary treatment to resolve chronic/recurrent appendicitis is appendectomy, though at least one report suggests

that this may not be necessary in younger patients²⁶. Among the diagnostic modalities, USG has proven to be very accurate in skilled hands with a sensitivity >85% and specificity >90%. The normal appendix is a compressible blind-ending tubular structure that lacks peristalsis and indicators of AA include visualizing a noncompressible appendix, with a diameter >6 mm and/or a wall thickness >2 mm, lack of air in the appendiceal lumen, periappendiceal fat stranding, presence of appendicolith, complex right lower quadrant mass, enlarged mesenteric lymph nodes, presence of free fluid²⁷. Several meta-analyses have been conducted to evaluate the use of ultrasound for the diagnosis of acute appendicitis. Terasawa et al reported that the sensitivity and specificity of ultrasound for the diagnosis of acute appendicitis in their study were 86% and 81%, respectively, and that computed tomography was more accurate than ultrasound in the diagnosis of acute appendicitis. In addition, Yu et al analyzed a Korean study and reported that the sensitivity and specificity of ultrasound for the diagnosis of acute appendicitis in their study were 86.7% and 90.0%, respectively. Field et al conducted a meta-analysis of 21 studies on the diagnosis of acute appendicitis using ultrasound. The results of their study indicated that the sensitivity and specificity of POCUS for the diagnosis of appendicitis were 91% (95% CI = 83%–96%) and 97% (95% CI = 91%–99%), respectively. Lee et al conducted a meta-analysis of 17 studies on the use of POCUS for the diagnosis of acute appendicitis, and reported that the pooled sensitivity of POCUS for the diagnosis of acute appendicitis was 84% (95% CI: 72%–92%), whereas the pooled specificity was 91% (95% CI: 85%). In addition, they reported that ultrasound showed significantly better diagnostic performance for pediatric acute appendicitis (sensitivity, 95%; 95% CI, 75%–99%; specificity, 95%; 95% CI, 85%–98%)²².

CONCLUSION

This systematic review highlights the diagnostic accuracy of sonography in assessing inflamed acute appendicitis. Inflamed acute appendicitis is a common surgical emergency that, when diagnosed and treated promptly, typically has a good prognosis with most people recovering quickly and completely.

Ultrasound is an accurate means of diagnosing/excluding appendicitis or suggesting an alternate diagnosis. Routine and liberal use of US should be made in cases of suspected appendicitis to reduce both negative appendectomy rates as well as perforation rates.

AUTHOR CONTRIBUTION

Author	Contribution
Laiba Rangeen	Manuscript writing, Conceptualization, and methodology
Muhammad Zubair	Supervision, review of methodology, and editing of the final draft.
Muhammad Ibrahim Khan	Data extraction, risk of bias assessment, data synthesis, and critical revision of the manuscript.
Tehmina Kouser	Quality assessment, formatting, reference management, and proofreading

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