

## Investigating Diagnostic Value of Ultrasonography in Acute Appendicitis

### Abstract

**Background:** Acute appendicitis is one of the most commonly diagnosed surgical diseases that its accurate diagnosis is still a problem, and there is no certainty. Ultrasound is recommended for diagnosis of appendicitis as an easy and noninvasive method. Therefore, due to the spread of disease and the urgent need to accurately diagnose in all educational centers, we decided to determine the diagnostic value of this inclusive method in identifying acute appendicitis. **Materials and Methods:** This is a descriptive cross-sectional research that was conducted on 540 patients referring to Educational Center of Ayatollah Kashani Hospital. All individuals suspected to appendicitis, and undergone ultrasound was included in the study, and then the result of ultrasound was compared to the obvious pathological results. Data were entered into statistical software of SPSS 20 and were analyzed. **Results:** According to the ultrasound findings, appendicitis was diagnosed as negative in 351 ones and positive in 189 ones. Ultrasound sensitivity in the diagnosis of appendicitis was 37.1%, while its specificity was 87.2%. The positive predictive value was 96.8% and the negative predictive value was only 11.7%. **Conclusion:** Considering very low-negative predictive value in educational centers, it is suggested that ultrasound is done for diagnosis of appendicitis only in complicated cases of appendicitis and differential diagnose (kidney stones, and ovarian cysts). In addition, it is recommended that routine ultrasound be avoided for all patients.

**Keywords:** Acute appendicitis, sensitivity, specification, ultrasound

### Introduction

Acute appendicitis is one of the most common surgical emergencies.<sup>[1]</sup> Appendicitis is often seen in the second to fourth decade of life, and about 7% of the population suffering during their lifetime,<sup>[2]</sup> and men are less likely to involve with 13% than women with 25%<sup>[2]</sup> with a higher risk in teenagers.<sup>[3-5]</sup> The diagnosis of acute appendicitis is a clinical diagnosis based on the findings from the patients' history and physical examination.<sup>[3,6]</sup> One of the criteria for diagnosis based on clinical signs and examinations is the Alvarado standard, which includes symptoms (abdominal pain and migration, nausea and vomiting), symptoms (anorexia, tenderness and rebound tenderness, fever), and laboratory criteria (leukocytosis and left shift).<sup>[7]</sup> However, abnormal forms of acute appendicitis, especially in pediatrics, young women, elderly, pregnant women, and those who have taken antibiotics, cause the appendix to be removed in 15%–30% of cases.<sup>[8,9]</sup> Methods for reducing

appendectomy and decreasing morbidity and mortality of appendicitis are highly sought by the scientific community.<sup>[4,10,11]</sup>

Hence, timely and correct diagnosis of appendicitis is necessary so that complications resulting from appendicitis rupture such as peritonitis, phlegmon, and abscess can be reduced.<sup>[12]</sup>

Late diagnosis of appendicitis is associated with an increase of disability and mortality. In addition, incorrect diagnosis of appendicitis imposes unnecessary surgery to the patient, and leads to the lack of recovery of the main problem following the operation and patient's dissatisfaction with the medical system.<sup>[6]</sup> The preoperative diagnostic accuracy is about 85%, and if this rate is consistently low, it indicates an increase in the number of unnecessary surgeries. On the other hand, if the consistently be above 90%, it is indicative that patients with appendicitis did not undergo surgery.<sup>[7]</sup> Although the clinical diagnosis of this disease is based on the patient history and physical examination, some patients lack the typical symptoms

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of acute appendicitis, and the results of early diagnostic procedures such as laboratory examinations and white blood cell counting are unclear and on the borderline. In these patients to differential diagnosis of appendicitis from other diseases of similar clinical indications, it is necessary to use more specific diagnostic methods such as laparoscopy, sonography, barium enema, computed tomography (CT) scan, magnetic resonance imaging, and radiolabeled leukocytes scanning.<sup>[13-15]</sup> Adult patients, which lack perfect clinical symptoms and suspected to acute appendicitis, should use ultrasound as the primary imaging, so that differential diagnosis put aside.<sup>[10]</sup>

Therefore, due to the prevalence of appendicitis and various comorbid diseases, studies are still underway to select the ideal diagnostic test in these patients and clinical observations, along with diagnostic imaging techniques, are important as a basic diagnostic tool.

Over the past two decades, using ultrasound and CT scan in patients with suspected appendicitis has had a correct preoperative diagnosis of 83%–98%.<sup>[4]</sup> Several studies have been performed on ultrasound, which show an effective contribution to the diagnosis of appendicitis and reported the sensitivity and specificity of more than 70%.<sup>[4,8,10,16]</sup>

Despite the fact that the role of ultrasound in the diagnosis of acute appendicitis has been proven, it is highly dependent on the experience, skill, and knowledge of the operator.<sup>[17,18]</sup>

On the other hand, unfortunately, in the educational centers, ultrasound is widely performed in all patients suspected of appendicitis and it is often done by the 1<sup>st</sup> year assistants who do not have enough experience which regarding the emergency conditions and a large number of patients and also the use of old devices in these centers it led to reduction in the accuracy of diagnosis. For this purpose, in this study, an ultrasound diagnostic value for identifying acute appendicitis cases in a large sample size of the Iranian population has been investigated in one of the major educational and therapeutic centers.

## Materials and Methods

This diagnostic type of study was done on the all patients suspected of acute appendicitis referred to Ayatollah Kashani Education Hospital in Isfahan during 1392–1396 that among them 650 patients were selected by the simple random method.

The reason of these patients' referring was mainly abdominal or pelvic pain, nausea and vomiting, anorexia, and fever. They were initially examined for clinical examination and due to ambiguous clinical symptoms and doubted physical examinations with suspicion of acute appendicitis, abdomen, and pelvic sonography were performed.

It should be noted that during this period, patients who referred with typical clinical indication of acute appendicitis

and whose physical and laboratory examinations were positive and who had undergone an emergency surgery without ultrasonography were excluded from the study. Therefore, most patients were suspected of acute appendicitis.

In addition, individuals that found pathologies other than appendicitis during or after surgery as well as those that were not able to participate such as individuals with mental disabilities and other obvious diagnoses of appendicitis were excluded from the study. Hence, the sample size was reduced to 540 patients.

At first in all patients, the lower quadrant of the abdomen was examined, in the situation of lying back, and ultrasound was done with gradual pressure of transducer from the umbilical region to the pelvic region on the right side of the abdomen. Abdomen and pelvic ultrasonography was performed for all patients.

Patients referring to Ayatollah Kashani Hospital in Isfahan with abdominal complaint were examined by one the medical service in the emergency department. Patients that were clinically diagnosed with acute abdominal pain underwent ultrasound in the same center.

After surgeon's examination and confirmation of susceptibility to appendicitis, preoperative routine tests were taken, they were sent to the operating room as soon as possible, and they underwent appendectomy by the same surgeon.

It should be noted that all samples were examined by a person who was not aware of the ultrasound results.

Finally, the results of pathology and ultrasonography of all patients with their demographic information such as age, sex, and BMI were recorded and entered into SPSS (Version 20) software. To assess the diagnostic value of ultrasound in comparison with the pathology of the Receiver Operating Characteristic (ROC) was used. Furthermore, the significance level in all analyzes was considered to be <0.05.

## Results

In the current study, from 540 patients suspected to acute appendicitis participated, 280 (51.9%) were male and 260 (48.1%) were females with the mean age range of  $24.88 \pm 11.50$ . In addition, results obtained from the pathology of patients were identified as normal in 47 ones (8.7%) and as appendicitis in 493 ones (91.3%) [Table 1].

In addition, pathological diagnosis of appendicitis was positive in 493 ones, and it was negative in 47 cases. According to ultrasonography findings, appendicitis was negative in 351 ones and positive in 189 ones. Ultrasonography sensitivity in the diagnosis of appendicitis was 37.1% (183.493), while its specificity was 87.2% (41.47). Its positive predictive value was

96.8% (183/189) and its negative predictive value was only 11.7% (41/351) (area under the ROC curve [AUC] = 0.622,  $P = 0.006$ ) [Table 2].

Finally, Figure 1 evaluates the diagnostic value of ultrasonography in the diagnosis of appendicitis compare to patient's pathological findings in terms of gender. According to this figure, diagnostic value of ultrasonography for appendicitis is no acceptable and significant for women (AUC = 0.560,  $P = 0.2177$ ), while it has significant diagnostic value in men ( $P < 0.05$ ).

### Discussion

In our study, which was conducted during 2013–2017 on patients referring to Educational Center of Ayatollah Kashani Hospital, 540 patients were entered into the study. Out of 540 patients, 493 ones (91.3%) showed acute appendicitis in the pathological examination, and 47 ones (8.7%) had negative appendectomy. Through ultrasonography, appendicitis was reported in 351 patients (65%) and positive appendicitis was reported in 189 patients (35%).

In line with our study, in a study on the diagnostic value of ultrasonography in appendicitis by Sezer *et al.* it has been reported the sensitivity of 71.4%, specificity of 78.5%, positive predictive value of 94.8%, and negative predictive value of 33.3%<sup>[19]</sup>

In the study by Nasiri *et al.* sensitivity was reported as 71.2%, specificity was 83.3%, positive predictive value was 97.4%, and negative predictive value was reported as

**Table 1: Major clinical characteristics of patients under study**

Characteristics	Total (n=540), n (%)
Sex	
Male	280 (51.9)
Female	260 (48.1)
Age (year)	24.88±11.50
BMI (kg/m <sup>2</sup> )	28.61±4.92
Pathology	
Negative	47 (8.7)
Positive	493 (91.3)

BMI: Body mass index

**Table 2: Ultrasonography findings compared with pathological findings for diagnosis appendicitis**

Ultrasonography	Pathological		Total
	Appendicitis	Normal	
Normal	310 (62.9)	41 (87.2)	351
Appendicitis	183 (37.1)	6 (12.8)	189
Total	493	47	540

AUC=0.622,  $P=0.006$ . Sensitivity=37.1%, specificity=87.2%.  
 Positive predictive value=96.8%, negative predictive value=11.7%.  
 Data presented in (%). AUC: Area under the ROC curve,  
 ROC: Receiver operating characteristic

25%. It denotes that ultrasonography provides reliable and valuable findings for diagnosis of appendicitis.<sup>[20]</sup>

Al-Ajerami *et al.* also indicated that the sensitivity and specificity of ultrasound were 84.8% and 83.3%, respectively, with a positive and negative predictive value of 93.3% and 66.7%, respectively.<sup>[16]</sup>

In the study of Kaneko and Heinz, ultrasonography in patients with acute abdominal pain was introduced as a selective technique in emergency situations, which contributed to elimination of the other differential diagnoses.<sup>[21]</sup> Another study assessed the ultrasound diagnostic accuracy with graduated compression techniques in emergency situation at the patient's bed, but its sensitivity was low and was recommended to be combined with clinical and laboratory findings.<sup>[22]</sup>

However, in the current study, sensitivity in diagnosis of appendicitis was 37.1%, and its specificity was 87.2%. The positive predictive value is 96.8% and the negative predictive value is only 11.7%. It should be noted that most ultrasonography tests were done in emergency and out of official hours, and were done by radiology assistants. If radiologists did the tests it is probable that other findings would be obtained. However, conclusions made in similar educational centers probably would be very similar to our analysis. In a review study by Pinto, it was confirmed that ultrasonography indicates very variable diagnostic accuracy in diagnosis of acute appendicitis (sensitivity range from 44% to 100% and specificity from 47% to 99%). This is due to many reasons, including lack of operator skills, increased intestinal gas volume, obesity, anatomical types, and limitations for the discovery of patients with prior laparotomies.<sup>[4]</sup>

Although ultrasound in educational centers may have a low accuracy, it can be useful for differential diagnosis.

Considering very low-negative predictive value in educational centers, it is suggested that ultrasound is

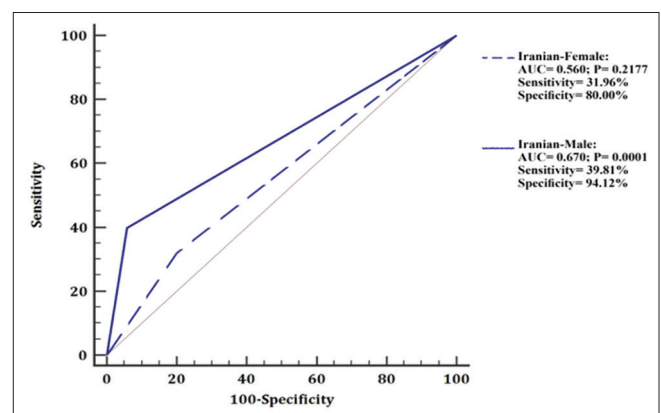


Figure 1: Comparison of ultrasonography compared with pathological findings for diagnosis appendicitis based on sex

done for diagnosis of appendicitis only in complicated cases of appendicitis and differential diagnose (kidney stones and ovarian cysts). In addition, it is suggested that routine ultrasonography is avoided for all patients suspected to acute appendicitis. Because the report of “currently no evidence for acute appendicitis was not observed, but ultrasonography did not reject appendicitis and compatibility with clinical and laboratory evidence is suggested” sometimes confuses patients and their relatives.

## Conclusion

According to the results of this study, ultrasonography has a low sensitivity in acute abdominal pain evaluation, especially in the cases of clinical and laboratory suspected acute appendicitis, and in contrast, it has a high accuracy and very low-negative predictive value.

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## Conflicts of interest

There are no conflicts of interest.

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