

Correlation between Clinical, Sonographic and Pathologic Findings of Patients Undergoing Appendectomy

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Abstract

Introduction: Acute appendicitis is the most common cause of acute abdomen and is considered as a surgical emergency. Approximately, 10% of patients with acute appendicitis and delayed diagnosis can face many complications. This study was designed to examine the correlation between ultrasound and pathological findings in patients with appendicitis and aimed to determine the diagnostic levels of ultrasound in these patients.

Methods: This study is a retrospective study conducted on 500 patients with clinical symptoms suggestive of appendicitis in 2010-2012 in the Ayatollah Kashani hospital. These patients have undergone appendectomy. Having collected clinical and ultrasound data and compared them with pathological results, the data were analyzed.

Results: In this study, 56.3% of patients were male and 43.7% of them were female. The mean age of the study population was 24.8±14.1 years. In this study, the sensitivity of ultrasonography in the diagnosis of acute appendicitis was 83% and its specificity was 56%. The positive predictive value of ultrasound in this study was 89.2% and the negative predictive value was 42.6%.

Conclusion: Based on these results and by comparing with those of other studies, the sensitivity and specificity of ultrasonography in the center is acceptable and is at the similar level to other centers. Besides, the accuracy of ultrasound in the negative cases is much more than the positive ones.

Keywords: Appendicitis, Sonography, Pathology, Sensitivity, Specificity

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1. Introduction

Acute appendicitis is the most common cause of acute abdomen and appendectomy is the most common emergency surgery for appendicitis worldwide. About 10% of people get acute appendicitis which if not diagnosed on time will cause many complications in the patient. The main symptom of appendicitis is abdominal pain which, classically, is an umbilical pain that gradually moves to the Right Lower Quadrant (RLQ) of the abdomen [1, 2]. Acute appendicitis is usually diagnosed according to the findings of the patient's history. The symptoms can occur in many forms and mimic the symptoms of other diseases; therefore, accurate and timely diagnosis of the disease requires special skills and experience [3]. As a result, the diagnosis of acute appendicitis in some cases can be a challenge and the use of imaging techniques is required. Advanced imaging techniques such as ultrasound and CT scan are used in the diagnosis of acute appendicitis. Use of these methods, especially in patients who have unspecified symptoms is very helpful [4]. Common forms of diagnostic and clinical utilization of other means to confirm the clinical diagnosis is popular in emergency centers [5]. Normal X-rays have little sensitivity for the diagnosis of appendicitis and typically is not recommended. Ultrasound is

recommended in the evaluation of acute appendicitis. Ultrasound is the preferred method and more suitable to diagnose appendicitis and is widely used in medical centers [1]. This study attempts to assess the correlation between ultrasound and pathological findings in patients with appendicitis and to determine the diagnostic extent of ultrasound in these patients.

2. Methods

The present study is a retrospective study which is performed on 500 patients with clinical symptoms suggestive of appendicitis who underwent appendectomy in the Ayatollah Kashani hospital of Shahrekord in 2010-12. The sample size was of 500 patients who had the required criteria of the study. This sample size is selected based on the formula to estimate average results of similar studies, with 95% confidence and a maximum absolute error of 0.5. The information obtained from the clinical examination (which results in suspicion to appendicitis) and also the results of the ultrasound and pathology as well as other demographic information obtained from the patient were recorded in the provided information form. The data gathering tool, reliability, validity and patient information forms were designed according to previous re-

searches conducted in this area. Alvarado number is also calculated in this study according to valid references listed here. The inclusion criteria for this study were: undergoing appendectomy and ultrasound in the course of hospitalization before performing appendectomy, referring to a pathologist post-surgery. The exclusion criteria for this study were excessive obesity prior to the surgery that causes improper diagnosis, any problem that prevents the possibility of imaging including requiring emergency surgery, the lack of required information (at least, results for sonography and pathology) in the patients' clinical history.

Having collected data on clinical findings, ultrasound and compliance with pathological results, the data were analyzed. The results of this study have been analyzed using SPSS 16 software through the average standard deviation, relative

abundance, Kappa coefficient and Chi-square test.

Findings from clinical ultrasound were corresponded with the results of pathological studies. Appendectomy patients were studied in terms of shift in pain, anorexia, nausea and vomiting, tenderness RLQ, rebound tenderness, fever, leukocytosis, and left shift.

Ultrasound in the supine position, the best position to assess the appendix, was performed using a linear probe with a frequency of 7.5-10 MHz and a gradual pressure technique.

A definite criterion for diagnosis of appendicitis was the presence of neutrophil cells within the muscular layer of the pathology specimens.

By using the data obtained from patients and the following formula, the Alvarado value was calculated and analyzed for patients (Table 1).

Table 1. Alvarado scoring system

Alvarado Score	Demonstration	Value
Signs	Shift pain	1
	Anorexia	1
	Nausea and vomiting	1
Symptoms	RLQ tenderness	2
	Rebound tenderness	1
	Fever	1
	Leukocytosis	2
Laboratory values	Left shift in the leukocyte count	1

Patients with the scores of 9 and 10 certainly have acute appendicitis. Patients with the scores of 7 and 8 are likely to have acute appendicitis. While those with the points of 5 and 6 do not contradict appendicitis, they are not diagnostic, either. In patients with the scores between 0 and 4, the likelihood of appendicitis is low [1].

All the collected data about individuals were kept strictly confidential and were used only for research purposes. Ultrasound in the diagnosis and treatment processes was at the routine request of the physician; therefore, no cost was imposed to the patient. The results are reported collectively.

3. Results

In this study, 56.3% were male and 43.7% were female. The mean age of the study population is 14.1 ± 24.8 years. The Maximum and minimum age in this study was 89 and 3 years, respectively.

Clinical symptoms in patients who have undergone appendectomy, are as follows:

Laboratory data from the patients were collected to determine the presence of leukocytosis and left shift in the white blood cells. Table 2 and 3 shows the results.

Later in this study, using the formula given in Methods, the Lvardv value was calculated for all patients; the average of which is 2.52 ± 6.42 and it's highest and lowest are 9 and 0, respectively.

Table 2. Frequency of clinical symptoms in appendectomized patients

Title	Number of Individuals	Percent
RLQ tenderness	435	89.5
Rebound tenderness	221	45.8
Fever	98	20.5
Loss of appetite	315	67.6
Nausea and vomiting	369	75.9
Pain Shift	230	48.4

Table 3. Laboratory findings in appendectomized patients

Title	Number of Individuals	Percent
Leukocytosis	365	76.7
Left shift	347	74

In order to facilitate the reviews, people were classified. According to this classification those who had an Lvardv number more than 5 were considered likely to have acute appendicitis and others were considered without this risk. Based on this classification, 77% of the patients were likely to develop appendicitis.

All the patients in this study underwent ultrasound examination to confirm the diagnosis pre-surgery. Based on the results, 75.7 % of the people have had symptoms of acute appendicitis in ultrasonography; however, the results of 24.3 % patients' ultrasound examination was negative.

The samples which were obtained after appendectomy surgery were sent to the pathology laboratory for a final confirmation and diagnosis. The results show that the pathology in 81.5 % of the patients was positive and their acute appendicitis diagnosis was done properly. In the case of 18.5 % of the people who have had surgery, their diagnosis of acute appendicitis were rejected.

Ultrasound and pathology findings in patients who have undergone appendectomy are given in the table below (Table 4).

Table 4. Comparison of sonography's diagnosis per pathology results

Pathology		Results	Ultrasound
Negative	Positive		
41 (8.1%)	340 (67.6%)	Positive	
52 (10.3%)	70 (13.9%)	Negative	

Based on statistical tests, sensitivity of ultrasound is 76.9 % and its specificity is 27.8 %. False negatives are 17.8 % and false positive are 16.6 %. Its positive predictive value is 78.1 % and reported negative predictive are 26.4 %.

Based on the Chi-square test, P value between sonographic findings and Lvardv value was 0.294.

4. Discussion

Acute appendicitis is considered to be the most common acute abdominal surgery. In many patients in need of surgery, clinical rating is a criterion for diagnosis and beginning treatments [6]. Usually, the diagnosis of acute appendicitis is performed based on the findings of the patients' history, clinical and laboratory data [3]. The accuracy of clinical diagnosis of acute appendicitis varies between 76% and 92%. Due to the possibility of numerous complications as the result of delays in diagnosis, doctors have adopted a negative appendectomy rate of 15-25% [1, 3]. If we can reduce negative appendectomy cases with the help of imaging techniques such as ultrasonography, there would be a major advance in the management of these patients. Regarding the above-mentioned, in this study, clinical, ultrasound and pathology findings in patients who have undergone appendectomy were compared.

In this study, the mean age of the participants is 14.1 ± 24.8 years. In reference books and various studies done in this field, the second to fourth decades have been reported to be the most common age of appendicitis. The results of the present study also indicate these findings.

In addition, in this study, similar to other studies, the percentage of men was higher compared to women.

In a study by Chandrasegaram et al., the acute appendicitis incidence was 71.3% and the positive appendectomy was 76.3%, while negative appendectomy was significantly lower in men compared to women [7].

The main symptoms of acute appendicitis are per umbilical pain, anorexia, and nausea. Despite the technological advances in the preoperative diagnosis of acute appendicitis, the correct diagnosis can only be made in 76-92% of the patients [8, 9].

Leukocytosis is observed in 80-90% of appendicitis cases; however, the leukocyte number is below 18.000 mm³ unless perforation is present [10]. In a study by Hatipoglu et al. leukocyte counts were high in patients with acute and perforated appendicitis in 95% and 93%, respectively [11].

The Alvarado score is utilized to determine the likelihood of appendicitis based on clinical signs, symptoms, and laboratory results. Among the 300 patients, 85.66% had Alvarado scores of 7 or less and 14.33% had scores greater than 7. For patients with confirmed appendicitis, 25.7% had Alvarado scores of 7 or less, whereas 93% had Alvarado scores greater than 7 [12].

In this study, the average value of Alvarado was 2.52 ± 6.42 and based on the Alvarado value, 77% of patients were likely to develop appendicitis. Looking at the results of other studies, we observed that the sensitivity and specificity of Alvarado were 74.8% and 68.4% respectively. Also, a negative appendectomy rate of 7 points or more, Alvarado criteria of 5.7%, and a positive predictive value of 98.1% was observed. The diagnostic accuracy of the Alvarado criteria in points 7 and more was 74% [13]. In Laal et al.'s study, diagnostic accuracy of the Alvarado score which was greater than six was reported as 88% and ultrasound results were 71.9 % [14].

The diagnosis of appendicitis has been largely based on physical examination findings. During the last decade, the use of diagnostic imaging has superseded the clinical examination. The application of Ultrasound for the diagnosis of acute appendicitis in children was first described in 1981 and expanded during the next two decades [15-17]. In a pooled analysis, the ultrasound was reported as 85% sensitive and 94% specific for diagnosing appendicitis [18]. Advantages include noninvasive nature and no risk of exposure to ionizing radiation [16, 19, 20], decreased negative appendectomy rate, perforation rate, and lower costs [15, 21, 22].

In this study, 75.7 % of the cases had symptoms of acute appendicitis on ultrasound; however, the result of 24.3% of patients' ultrasound examination was negative. In a study conducted by Amanallahi et al., 12.7 % of the patients had negative ultrasound results for the presence of appendicitis and 81.1% had a positive result for appendicitis [23]. In addition, in a study conducted by Mohammadi et al., ultrasound result of 67.8% was reported as acute appendicitis and 32.2% as normal [24]. Comparing the results obtained in this study with the similar studies, the performance of Ayatollah Kashani hospital radiology department was acceptable and parallel to other centers of the country.

Consistent with the results of histo-pathologic specimens, ultrasound results revealed that pathology of 81.5% of patients was positive for acute appendicitis, and that it was done properly. But for 18.5% of patients who had surgery, the diagnosis of acute appendicitis was rejected. In Amanallahi et al.'s study, 14.9% and 85.1% of the patients had negative and positive histological responses for appendicitis, respectively [23]. Sixty eight and 32percent of the patients undergoing appendectomy in Mohammadi et al.'s study were reported with acute appendicitis by histopathological findings, and normal appendicitis, respectively [24]. Considering the results of similar articles, misdiagnosis of acute appendicitis in Ayatollah Kashani's hospital were less than the other centers and had a more acceptable level.

In this study, the sensitivity of ultrasonography in the diagnosis of acute appendicitis was 83% and its specificity was 56%. The positive predictive value of ultrasound was 89.2% and the negative predictive value was 42.6%. In a double-blind prospective study, sensitivity, specificity, and accuracy of ultrasonography for acute appendicitis were 56.6%, 78.4%, and 63%, respectively. The positive and negative predictive values were 85.3% and 44.49%, respectively [25].

In a meta-analysis, the pooled sensitivity and specificity were respectively 83% and 93% for the diagnosis of adult appendicitis [26]. False negativity rates of US are 10-32% [27-31]. Falsely negative US results could lead to unnecessary delays in diagnosis and increased morbidity and cost. Lower pain scores and increased abdominal wall thickness are significantly associated with false negativity of US examination for acute appendicitis. False negativity is increasing among patients with higher BMI and shorter pain durations [32].

In a study by Amanollahi et al, sensitivity and specificity of ultrasonography were 3.98% and 4.76%, respectively. Also, positive and negative predictive values of ultrasound were 95.7%, and 89.4%, respectively [23].

In the studies conducted in other parts of the world, similar results were obtained. According to the results obtained from a research conducted by Pacharn et al. in 2009 in Thailand, , negative predictive value of ultrasound was 95.1% [31].

In Chan et al.'s study, an ultrasonography accuracy of 92%, sensitivity of 83% and specificity of 95% have been reported. Also in this study, positive and negative predictive values were calculated 86% and 94% respectively [33]. Also, in a study conducted by Gracey et al. in the United Kingdom in 2007, the sensitivity of the diagnosis of appendicitis in general was 93.8% and the overall measured specificity was 91.3% [34].

The comparison of the sensitivity and specificity obtained in this study indicates that the sensitivity of ultrasonography in this center is similar to that of other centers both within and outside the country and is at an acceptable level. It can also be said that like other studies, the positive predictive value of sonographies was more than the negative predictive values. Therefore, at the time of positive ultrasound results, there is a very high chance of developing acute appendicitis.

Specificity and predictive values obtained in this study is slightly lower than that of other studies. The specificity and negative predictive values obtained in this study are reasonable and acceptable. Interpretation of the results of this study considering this point suggests that the sensitivity of ultrasonography in this center has been higher and mistakes were lower than in other centers.

Based on these results and comparing them with the results of other studies, the sensitivity and specificity of ultrasonography in this center is acceptable and has the same level as other centers. Also, the accuracy of ultrasound in positive cases has been much more than that of negative ones. As a

result, after clinical suspicion of acute appendicitis in patients, false negative cases should be reduced by ultrasound to avoid unnecessary surgical procedures.

5. Conclusions

Considering ultrasound as an accurate diagnostic tool for assessing pathological processes in every part of the body is accepted worldwide. This is why it is used in most medical centers around the world as a routine diagnostic test. In general, the results of this study shows that in the diagnosis of appendicitis ultrasound is valuable and acceptable in the current situation of our society and we can use ultrasound to help diagnose patients with suspected acute appendicitis prior to surgery. Ultrasound can help with early detection and treatment which reduces the incidence of side effects and complications and on the other hand, negative appendectomy cases and hospital costs and avoids unnecessary surgery. Since ultrasound results depend on the skill of the operator, achieving such outcomes directly depends on the experience of the radiologist performing this technique and his familiarity with principles of the GI tract ultrasound.

Suggestions

1. Conducting long-term studies with larger sample sizes in order to monitor the accuracy, sensitivity and specificity of ultrasonography in the diagnosis of acute appendicitis
2. Conducting long-term studies with larger sample sizes in order to compare the effect of radiologist expertise in ultrasound
3. Conducting other researches by different radiologists and using their findings as diagnostic criteria in the case of being consistent with other findings

Limitations and problems of the implementation:

This study was very time-consuming and in some cases, recorded files were incomplete and necessary data were unavailable.

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Authors' Contribution

The authors were involved in the study design, data collection, interpretation of the results, and preparation of the manuscript.

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