



## Accuracy of Ultrasonography in Diagnosing Acute Appendicitis

Parisa Javidi Parsijani<sup>1</sup>, Nima Pourhabibi Zarandi<sup>1</sup>, Shahram Paydar<sup>2\*</sup>, Hamidreza Abbas<sup>2</sup>, Shahram Bolandparvaz<sup>2</sup>

<sup>1</sup>Trauma Research Center, Department of Surgery, Shiraz University of Medical Sciences, Shiraz, Iran

<sup>2</sup>Trauma Research Center, Shiraz University of Medical Sciences, Shiraz, Iran

**Corresponding author:** Shahram Paydar

Address: Trauma Research Center, Shiraz University of Medical Sciences, Shiraz, Iran.  
Tel./Fax: +98-711-6254206 e-mail: paydarsh@gmail.com

Received: August 30, 2013

Revised: September 25, 2013

Accepted: September 30, 2013

### ► ABSTRACT

**Objectives:** To evaluate the accuracy of sonography in diagnosing acute appendicitis in patients with Alvarado score 4–7.

**Methods:** This is a retrospective cross-sectional study being performed in Namazee hospital affiliated with Shiraz University of Medical sciences during a one year period from 9/2007 to 9/2008. We evaluated all patients with Alvarado score 4-7 and divided them in two groups: those with Ultrasound study prior to surgery and those without any imaging modalities for diagnosis of AA. The demographic information, histopathology, physical examination, laboratory data, sonography report and histopathological reports of patients were gathered.

**Results:** A total of 238 patients had Alvarado scores 4-7 including 160 males and 78 females. 110 patients did not have any imaging and 128 had undergone sonography before operation. Ultrasound had overall sensitivity of 75 %, specificity 69.2 %, PPV 88 %, NPV 46.1% and accuracy of 73.6 %. Negative appendectomy rate was 20.9 % and 23.4 % in those without sonography and inpatients with sonography respectively, with a higher rate in females.

**Conclusion:** Ultrasound is more useful when the patient is female and the result of sonography is positive; however, it is not reliable when the result is negative and maybe other diagnostic modalities such as CT scan can help us in better diagnosis of Acute Appendicitis.

**Keywords:** Acute Appendicitis; Ultrasound; Alvarado Score; Sonography.

Please cite this paper as:

Javidi Parsijani P, Pourhabibi Zarandi N, Paydar S, Abbasi HR, Bolandparvaz S. Accuracy of Ultrasonography in Diagnosing Acute Appendicitis. *Bull Emerg Trauma*. 2013;1(4):158-163.

### Introduction

Acute appendicitis (AA) is with no doubt one of the most common causes of surgical emergencies worldwide [1]. Appendectomy is the gold standard treatment for AA [2]. A successful outcome depends on an early diagnosis followed by appendectomy before development of any complication such as gangrene or perforation [3,4].

Several scoring systems have been used globally for early diagnosis of AA. One of the most practical scoring systems is the Alvarado scoring system which is based on history, physical examination, and some laboratory investigations that are convenient to apply

[5-7]. Nevertheless, definite diagnosis can only be made after the operation and by histopathology examination of the collected specimens [8]. The alvarado score consists of 8 parameters [5] (Table 1). Patients with Alvarado scores of 9 or 10 almost certainly have AA, so the accepted management for these patients is to proceed with appendectomy as soon as possible without further work up [2,9]. Patients with scores 0-4 have very low chance of having appendicitis and imaging studies are not recommended for them as well [2]. Those that have scores of 7 and 8 are still very likely to have appendicitis and scores of 5 or 6 are not exactly diagnostic but may

still have AA [2,9]. These clinically equivocal cases need further investigations helping with the diagnosis [9]. Computed tomography (CT scan) has been shown in many studies, to be highly sensitive and specific for diagnosing AA and is fewer operators dependent [9-12]. Graded compression sonography is also a very useful tool in establishing the diagnosis of acute appendicitis. It is inexpensive compared to CT, can be performed rapidly and does not require a contrast dye or radiation exposure especially in pediatric field. [1,10-16] It is also possible to have a dynamic view of all abdominal organs as well [10]. We take advantage of ultrasound commonly at our center to diagnose acute appendicitis. Thus, it is important to evaluate the accuracy of ultrasound in the diagnosis of AA in equivocal cases in our own center.

## Material and Methods

### Study population

This study is a retrospective cross sectional study. All of the acute appendicitis patients at our center had open appendectomy due to the facility availability of equipment. This study included the patients who referred from 09/2007 to 09/2008 to Nemazee Hospital, a tertiary healthcare center, affiliated with Shiraz University of Medical Sciences. We evaluated all the patients who had undergone open appendectomy, with Alvarado scores between 4-7 and divided them in two groups: One group were those patients that had ultrasound study as an accessory modality for diagnosing AA (abdominopelvic ultrasound with graded compression technique for appendicitis which was carried out by radiology resident) prior to their surgery and 2<sup>nd</sup> group were those who did not have any imaging study before their surgeries. Diagnosis of AA was made through “acute appendicitis” or “gangrenous appendix” written in the histopathology results of the appendectomy. Our exclusion criteria were lack of histopathological report, Alvarado score below 4 and above 7 and incomplete information needed for calculating the Alvarado score. The study protocol was approved by the institutional review (IRB) board and medical research committee of Shiraz University of Medical Sciences. As this was a retrospective study, no informed written consents were required.

### Study protocol

All data including the demographic information, history, physical examination, and laboratory data such as leukocytosis, ultrasound and histopathological reports were gathered from the medical records. We then calculated the Alvarado score with the data in the patients' files. Our criteria for positive ultrasound was the exact phrase “in favor of appendicitis” written in

report. We also evaluated those cases with sonography reports of “suspicious of appendicitis” separately to evaluate the value of these reports as well. Leukocytosis was considered as WBC  $\geq 10,000$  and central body temperature above 37.5 °C was accounted as fever. Unfortunately, we could not evaluate shift to the left of leukocytosis which was one of the limitations of our study.

### Statistical analysis

We made our statistical analysis by using The Statistical Package for social Sciences, SPSS version 19.0 (SPSS Inc., Chicago, IL) and descriptive results are presented as mean  $\pm$  standard for 95% confidence interval (CI) or proportions as appropriate.

## Results

A total of 377 patients had undergone open appendectomy during one year in our center. 238 patients had Alvarado score between 4 and 7. One hundred and sixty of them were male (67.2%) and 78 patients were female (32.8%), with male to female ratio of approximately 2:1. Sixty seven male and 61 female patients had ultrasound study prior to their surgery. Patients' age ranged from 4 to 76 years old with mean age of  $16.86 \pm 12.46$ . Four patients were less than 5 years old (3.1%), 73 patients were between 5 and 16 years old (57%), 49 patients were between 16 and 60 years old (38.3%) and 2 patients were older than 60 years old (1.6%).

Of all the 238 patients, 185 patients had acute appendicitis confirmed by histopathological reports (77.7%), 7 patients had normal appendix (2.9%) and 46 patients had other diagnosis. 40 of them had diagnosis of lymphoid follicular hyperplasia and 6 of them had other pathologies. None of the patients had malignancy. Total negative appendectomy rate was 22.3%.

Among the patients who had ultrasound study, 98 patients had acute appendicitis (76.6%) (Confirmed by histopathology) and 30 patients had normal pathology or other diagnosis (23.4 %). Negative appendectomies were significantly higher in females (22 were female and 8 were male) (Table 2).

From 98 patients that had appendicitis, ultrasound results were in favor of appendicitis in 63 patients (64.3%) and were suspicious for appendicitis in 14 patients (14.3%). Twenty One patients had normal study (21.4%). In 8 patients out of those 30 patients with normal appendix or other pathologies, ultrasound study was in favor of appendicitis (26.7% of these 30 patients) and was suspicious of acute appendicitis in 4 of them (13.3%). Ultrasound results were normal or showed other pathologies in 18 patients (60%). Overall, Sensitivity and specificity

**Table 1.** Alvarado Score [5]

	Manifestations	Score
<b>Symptoms</b>	Migratory pain	1
	Anorexia	1
	Nausea and/or vomiting	1
	Right lower quadrant tenderness	2
<b>Signs</b>	Rebound tenderness	1
	Fever	1
	Leukocytosis	2
<b>Laboratory data</b>	Shift to the left in leukocyte count	1
	<b>Total</b>	10

of ultrasound in diagnosis of acute appendicitis was 75% and 69.2%, respectively. Due to small number of patients in both extreme age groups (below 5 and more than 60) it was impossible for us to calculate these equations separately for them; In 5 to 16 years old patients, sensitivity and specificity of ultrasound in diagnosis of acute appendicitis was 76% and 66.7% respectively and in ages between 16 to 60, sensitivity was 71.8% and specificity was 72.7%. The overall accuracy of ultrasound in our study was 73.6%. The positive predictive value and the negative predictive values of ultrasound were 88% and 46.1% respectively. In age group of 16-60, accuracy was 72%, positive predictive value was 88.4% and negative predictive value was 47%. In age group 5-16 years the accuracy of sonography was 73.7%, positive predictive value was 87.5%. Negative predictive value was 47.6%. We also calculated positive predictive value of the suspicious results of ultrasound for acute appendicitis which was 77.7%. (True suspicious: 14 cases, false suspicious cases: 4). Ultrasound was not done for 110 patients. From these patients 93 of them were male (84.5%) and 17 of them were female (15.5%). Negative appendectomy rate was 20.9% (n=23).

Rate of perforated appendicitis in the group of patients with prior ultrasound study was 18% (n=23) and it was 8.2% (n= 9) in patients who did not have ultrasound.

## Discussion

Acute appendicitis is one of the most common

etiologies of acute abdomen that leads to operation [17]. Almost 7% of people undergo appendectomy due to diagnosis of acute appendicitis during their lifetime [18]. Although it is a very common pathology its diagnosis still remains a challenge because it mimics many other conditions clinically [19]. Differential diagnosis of acute appendicitis are, but not limited to, mesenteric lymphadenitis, gastroenteritis, constipation, right lower lobe pneumonia and numbers of urologic or gynecologic diseases [20].

Normal appendix in ultrasound study is a compressible blind ended structure with the diameter of less than 5mm. On the other hand, inflamed appendix has an anteroposterior diameter of  $\geq 6$ mm and is non-compressible [2]. The existence of appendicolith in sonography also establishes AA [21]. Pathologic criteria that are in favor of tissue diagnosis of acute appendicitis are infiltration of neutrophils in mucosa of the appendix and focal superficial ulceration of the mucosa. However, they are not definite for diagnosis of AA [22].

Some studies suggest CT scan as a modality of choice in diagnosis of questionable cases of AA [9,12,19]. On the other hand some other studies recommend primarily ultrasonography as a modality of choice in diagnosis of equivocal patients and CT scan should be only used for those that have inconclusive US [1,20,23-26]. Ultrasound has many advantages; it can be done quickly, it is rather cheap, requires no preparation of the patient, does not need ionizing radiation nor any contrast [27]; plus, we do not have access to CT scan for patients suspected of acute appendicitis in our hospital setting due to large number of patients admitted in ER and relatively lower number of CT scan machines and the importance of time in diagnosis of AA. So in patients with equivocal signs of AA, it is the only accessory modality that can help the surgeon.

According to some studies ultrasound has a sensitivity ranging from 49 to 90 %, a specificity ranging from 47 to 100 %, a positive predictive value of 84 to 93 %, and an overall accuracy of 72 to 94 % for the diagnosis of AA [8,27-30]. In our study, sonography had overall sensitivity of 75% which was not significantly different in any age groups or sex. Its

**Table 2.** Analytic results for patients with ultrasonography as an accessory modality of diagnosis

	Overall	5 – 16 years	16 – 60 years	Males	Females
<b>Sensitivity (%)</b>	75%	76%	71.8%	77.5%	71.4%
<b>Specificity (%)</b>	69.2%	66.7%	72.7%	42.8%	78.9%
<b>PPV (%)</b>	88%	87.5%	88.4%	90%	86.2%
<b>NPV (%)</b>	46.1%	47.6%	47%	21.4%	60%
<b>Accuracy (%)</b>	73.6%	73.7%	72%	73.2%	74%

**Table 3.** Comparing the result of ultrasonography with histopathology findings, in different genders and age groups (Percentages are of patients with ultrasonography)

	Histopathology Findings		Total
	Acute Appendicitis	Normal or other pathologies	
<b>Acute Appendicitis (%)</b>			71 (55.5%)
Male (%)	38 (29.6%)	4 (3.1%)	42
Female (%)	25 (19.5%)	4 (3.1%)	29
< 5 years (%)	3 (2.3%)	0	3
5 – 16 years (%)	35 (27.3%)	5 (3.9%)	40
16 – 59 years (%)	23 (17.9%)	3 (2.3%)	26
≥ 60 years (%)	2 (1.6%)	0	2
<b>Suspicious of AA (%)</b>			18 (14%)
Male (%)	10 (7.8%)	1 (0.7%)	11 (8.6%)
Female (%)	4 (3.1%)	3 (2.3%)	7 (5.5%)
< 5 years (%)	0	0	0
5 – 16 years (%)	9 (7%)	3 (2.3%)	12 (9.4%)
16 – 59 years (%)	5 (3.9%)	1 (0.7%)	6 (4.7%)
≥ 60 years (%)	0	0	0
<b>Normal or other (%)</b>			39 (30.5%)
Male (%)	11 (8.6%)	3 (2.3%)	14(10.9%)
Female (%)	10 (7.8%)	15 (11.7%)	25 (19.6%)
< 5 years (%)	1 (0.7%)	0	1 (0.7%)
5 – 16 years (%)	11 (8.6%)	10 (7.8%)	21(16.4%)
16 – 59 years (%)	9 (7%)	8 (6.2%)	17 (13.3%)
≥ 60 years (%)	0	0	0
<b>Total (%)</b>	98 (76.6%)	30 (23.4%)	128 (100%)

overall specificity of was 69.2% which was significantly higher in female group (78.9% compared to 42.8%). Positive predictive value of ultrasound was 88% which was almost the same between different age groups and sex. However, our negative predictive value was low (46.1%) and was significantly less in our male group (21.4% compared to 60%) (Table 3). This should lead us to the conclusion that when ultrasound report is normal we should more rely on our clinical judgment than the report or perhaps use another modality such as CT scan if possible. There is another study by Nasiri *et al.* that also showed a significant difference between positive and negative predictive value of sonography confirming our results (97.4% for PPV in comparison to 25% for NPV) [25]. We also evaluated those cases with “suspicious of appendicitis” report. PPV of suspicious report in our cases was 77.7%. This means that with this report, there is significantly more chance of positive appendicitis than those with normal reports.

Accuracy of ultrasound in our center was 73.6%

which is less than some other studies. Ultrasound has also some limitations as well, for example appendix can be covered by overlying gas or overriding bony pelvis. The site of the appendix can also influence on the possibility of evaluation of appendix by ultrasound (e.g. a retrocecal appendix). Obesity is another factor influencing the optimality of sonography [19,21,27]. Another problem is that we do not have enough data for the terms like “clinically equivocal” or “suspicious case” in literature to exactly guide us when to perform US. It is however recommended that CT scan is useful for those with Alvarado score between 5-8 [2].

Our total negative appendectomy rate was 22.3% (n=53). It was significantly less in male group that was 15.6% (n=25) compared to female group that was 35.9% (n=28). There was no same study as ours to evaluate negative appendectomy rates only between Alvarado scores of 4-7. 40 of our negative appendectomies were diagnosed as lymphoid follicular hyperplasia, 7 were normal and 6 of them had other pathologies. No malignancy case was

reported. We compared patients that had ultrasound prior to their surgeries and those who did not have. In the first group negative appendectomy rate was 23.4%. and in the 2<sup>nd</sup> it was 20.9%.

There were 23 cases of perforated appendicitis in the patients with prior ultrasound study but there were only 9 cases in those patients without any imaging modalities. From these 23 patients, ultrasound successfully diagnosed 14 cases, was suspicious in 6 cases and was falsely normal in 3 cases. The time from the onset of the disease to accurate diagnosis and treatment is critical in management of patients with acute appendicitis. Delay in diagnosis may cause increased risk of perforation and other complications [31]. In addition, ironically, ultrasound becomes less efficient when there is perforation because the appendix becomes compressible [2,21,27].

Ultrasound is a rapid modality that can be performed bedside; however, in our center it is not performed by a general surgery resident or radiologist in the ER. The procedure is performed by radiology residents in ultrasound room, so it takes some time to consult with radiology resident and send the patient to sonography room. For this reason, patients who undergo sonography will lose a considerable time. However, it is only a hypothesis because it was not possible for us in this study to exactly measure the time spent from the moment a patient appear to the ER till the time that ultrasound is done for him/her.

Important to mention here is that most of our patient who were proceeded with surgery without any further imaging studies were male patients. We do not know whether the gender of the patients have any effect on the perforation rate of acute appendicitis per se.

The biggest limitation of this study was the retrospective nature of it which made us dependent to what was being recorded in patient's files. Data regarding shift to the left of neutrophils was not available as well; so we had to omit this criteria from Alvarado score calculation; for the same reason we evaluated patients with alvarado score between 4-7 instead of 5-8. There are other studies however that have recommended a "modified alvarado score" plus ultrasound as a method of choice for diagnosing appendicitis. Modified Alvarado score is the Alvarado score missing the shift of left of leukocytes [25,32,33]. Another limitation of our study was lack of data regarding the exact amount of time that would take for a patient to undergo ultrasound study. .

In conclusion, ultrasound is more useful when the patient is female, and has 88% positive predictive value; however, it is not reliable when the result is negative and maybe other accessory modalities such as CT scan are required for a more accurate diagnosis. We also concluded that reports with "suspicious for AA" sentence have PPV of 77.7%.

**Conflict of interest:** None declared.

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