

## SENSITIVITY AND SPECIFICITY OF ULTRASONOGRAPHY IN CASES OF SUSPECTED ACUTE APPENDICITIS; RESULTS OF A CROSS-SECTIONAL SURVEY

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### ABSTRACT

**Objective:** To evaluate the accuracy of ultrasonography in the diagnosis of acute appendicitis.

**Study Design:** A cross-sectional validation study.

**Place and Duration of Study:** Department of radiology, Sheikh Khalifa Bin Zaid Al Nahyan Hospital Muzaffarabad, Azad Jammu and Kashmir, from Oct 2015 to Apr 2016.

**Material and Methods:** Patients, >18 years of age, who were clinically suspected to have acute appendicitis and scored 5 or higher on Modified Alvarado Scoring System were included through consecutive sampling. All participants underwent ultrasonographic examination while using graded-compression technique. The sonographically positive patients for acute appendicitis underwent surgery and the removed appendix was examined for the signs of inflammation. The sonographically negative patients for acute appendicitis were kept on conservative management. They were operated later if they did not show improvement with conservative management and their appendix was re-examined for signs of inflammation.

**Results:** Out of 100 patients, 64 were male and 36 were female (mean age: 30 ± 7 years). Ultrasonographic evaluation was positive in 72 patients and negative in 28 patients. Sixty-four sonographically positive patients had positive operative findings while 12 out of 28 sonographically negative patients for acute appendicitis had to be operated because they did not show improvement with conservative management. The sensitivity of ultrasonography was 84%, while specificity was 67% with positive predictive value of 89%, negative predictive value of 57%, and accuracy rate of 80%.

**Conclusion:** Ultrasonography, with a diagnostic accuracy of 80% was found effective in the diagnosis of acute appendicitis, and recommended as a screening tool in suspected cases of acute appendicitis.

**Keywords:** Abdominal pain, Accuracy, Appendicitis, Modified Alvarado scoring system, Negative predictive value, Positive predictive value, Sensitivity, Specificity, Ultrasonography.

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### INTRODUCTION

Acute appendicitis is still one of the most common surgical abdominal emergencies<sup>1</sup>. Because of overlap with other clinical conditions and associated significant morbidity, no single sign, symptom, or diagnostic test accurately confirms the diagnosis of appendicular inflammation in all cases<sup>2</sup>. However, the overall appendectomy rate has fallen over time due to availability of modern investigative tools like ultrasonography, computerized tomography

scan, and magnetic resonance imaging<sup>3</sup>. The ultrasonography is quick, readily available, cost-effective, non-invasive, and end-user safe investigation that yields relatively clearer diagnosis thereby reducing the negative appendectomy rates<sup>3</sup>. The purpose of this study was to evaluate the accuracy of ultrasonography in the diagnosis of acute appendicitis by evaluating its sensitivity, specificity, positive and negative predictive values in patients with suspected acute appendicitis presenting in Sheikh Khalifa Bin Zaid Al Nahyan (SKBZN) Hospital, Muzaffarabad, Azad Jammu and Kashmir. This study would add further information to the national statistics and help in better

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understanding the role of ultrasonography in our patients suspected of acute appendicitis.

**MATERIAL AND METHODS**

This was a descriptive cross-sectional validation study conducted at the SKBZN Hospital, Muzaffarabad, Azad Jammu and Kashmir, over a period of 6 months i.e. from October 2015 to April 2016. Following approval from the hospital ethical committee, all patients, >18 years of age, who were clinically suspected to have acute appendicitis and were admitted to the surgical department of SKBZN hospital during the study period, were included through non-probability consecutive sampling after informed consent. All the included patients were required

All studies were performed by a senior consultant radiologist using ultrasonography machine “My Lab Seven” (Esaote, Genova, Italy), first with 3.5 megahertz curvilinear transducer and then with 12 megahertz linear transducer. The patients were initially examined in the conventional supine position, followed by the left posterior oblique position at an angle of 45° with the horizontal and then in a “second-look” supine position. The ultrasonographic criteria for the diagnoses of acute appendicitis given by Maher and Dixon<sup>9</sup> was followed. The criteria included:

- Outer diameter of the appendix ≥ 7mm
- Lack of compressibility

**Table-I: Positive and negative predictive values.**

Groups based on sonographic findings	Positive on per-operative observation	Negative on per-operative observation
Sonographically positive	64 (TP*)	8 (FP**)
Sonographically negative	12 (FN***)	16 (TN****)

\*True positive, \*\*False positive, \*\*\*False negative, \*\*\*\*True negative

**Table-II: Findings of sonographically positive patients for acute appendicitis (n=72).**

Sonographic findings	Number of patients	Percentage
Compressibility	60	83.3%
Diameter ≥ 7mm	40	55.6%
Appendicolith	10	13.9%
Omental thickening	58	80.6%
Surrounding fluid	46	63.9%
Probe tenderness	66	91.7%

to score 5 or higher on the Modified Alvarado Scoring System; the system developed by Kalan et al.<sup>4</sup> for the clinical diagnosis of acute appendicitis, and effectively used by Jan et al.<sup>5</sup>, Malik et al.<sup>6</sup>, Nasiri et al.<sup>7</sup>, and Gujar et al.<sup>8</sup>. It included scoring on account of migration of pain to the right iliac fossa, anorexia, nausea or vomiting, tenderness in the right iliac fossa, rebound tenderness in the right iliac fossa, temperature > 37.3°C, and white cell count of >10 x 10<sup>9</sup>/L. Patients with diagnosed pregnancy, chronic infectious diseases like ileo-caecal tuberculosis, carcinoid tumours, and other neoplastic lesions of the appendix were excluded.

- Appendicolith
- Omental thickening
- Surrounding fluid or abscess
- Maximum tenderness over the appendix with probe

In general, ultrasonography was considered positive when at least two or more criteria were met and negative if the appendix could not be visualized, or a normal looking appendix was seen or another definite pathology not affecting the appendix was noted.

The study was performed in both transverse and longitudinal planes with a technique referred

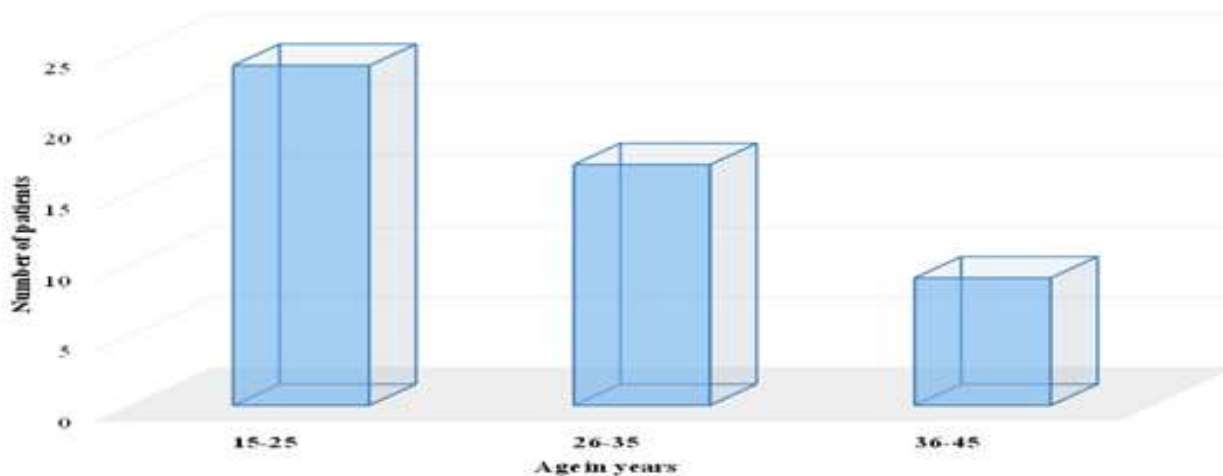
to as "graded compression" i.e. the radiologist exerted gentle pressure in the right iliac fossa to decrease the distance between the transducer and the retrocecal or retrocolic spaces, potentially increasing the resolution of the appendix. The ultrasonographic findings were recorded in a structured proforma. After ultrasonographic evaluation, the patients with a positive scan were sent for surgery and the removed appendix was observed for signs of inflammation. Patients in whom ultrasonography did not show signs of acute appendicitis, were kept on conservative treatment, and were operated later only if the symptoms did not resolve with conservative treatment.

For analysing sensitivity, specificity, positive

- FP: False positive (Positive on ultrasonography and negative on per-operative observation)
- TN: True negative (Negative on ultrasonography and did not require operation)
- FN: False negative (Negative on ultrasonography but needed operation after failure of conservative management)

**RESULTS**

Out of a total of 101 included patients, one patient dropped out as she refused treatment at the hospital after ultrasonographic evaluation. From the remaining 100 patients, there were 64 males and 36 females. The age of patients ranged



**Figure-1: Age distribution of the sample among patients.**

predictive value (PPV), and negative predictive value (NPV), we used the statistical software "MedCalc" (MedCalc Software, Ostend, Belgium). The accuracy of ultrasonography for acute appendicitis was estimated through following formula

$$\text{Accuracy} = \frac{TP+TN}{TP+TN+FP+FN} \times 100\%$$

Where;

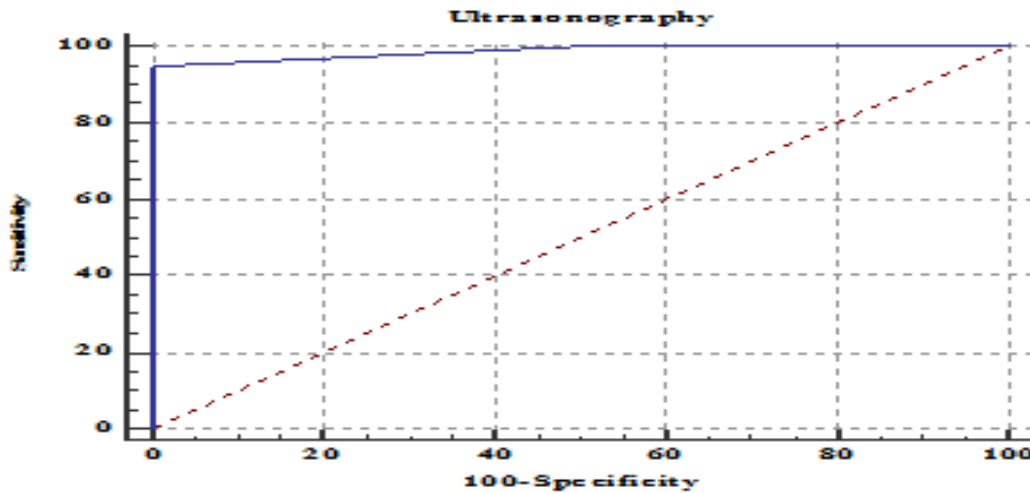
- TP: True positive (Positive on ultrasonography and per-operative observation)

from 15 to 45 years with a mean age of  $30 \pm 7$  years. The age distribution of the patients has been shown in fig-1. The ultrasonographic results of acute appendicitis were positive in 72 patients and negative in 28. The findings on ultrasonography have been shown in table-I. Sixty-four sonographically positive patients had positive operative findings while eight had a normal appendix on per-operative observation (table-II). All sonographically negative patients were kept on conservative treatment. Sixteen patients, later on, recovered fully, while twelve patients had to be operated upon as they did not

improve conservatively. All operated patients in this group had positive per-operative findings.

After analysis through MedCalc, the sensitivity of ultrasonography in the diagnosis of appendicitis was 84.21% (95% CI=74.04% to 91.57%), while specificity was 66.67% (95% CI = 44.68% to 84.37%), with PPV of 88.89% (95% CI=81.84% to 93.42%), and NPV of 57.14% (95% CI=42.47% to 70.66%). The accuracy rate calculated through the above-mentioned formula

We have observed the sensitivity of ultrasonography in the diagnosis of acute appendicitis as 84%, the specificity as 67%, PPV as 89%, NPV as 57%, and accuracy rate as 80%. The results can be compared to previous studies carried out in Pakistan. Hussain et al reported sensitivity of 88%, specificity of 92%, PPV of 94%, NPV of 86%, and diagnostic accuracy of 90%<sup>13</sup>. Arooj et al reported overall sensitivity of 94% and specificity of 84%<sup>14</sup>. Alia et al reported an overall specificity of 89.74% and the sensitivity of 96.72%,



**Figure-2: Receiver operating characteristic curve interpreting sensitivity and specificity levels among patients.**

was 80%. The receiver operating characteristic curve interpreting sensitivity and specificity levels has been given as fig-2.

**DISCUSSION**

Ultrasonography with its lack of ionizing radiations and effectiveness should be the investigation of choice in patients suspected of acute appendicitis. Puylaert JB was the pioneer investigator to promote graded-compression sonographic technique for diagnosing acute appendicitis in 1986<sup>10</sup>. The overall sensitivity of ultrasonography varies in different studies, but usually lies within the range of 75-95%, however, values as low as 44% have been reported<sup>11</sup>. The specificity of ultrasonography is usually reported to lie within the range of 90-95%, though substantially low values have been reported<sup>12</sup>.

PPV of 93.65%, and NPV of 94.59%<sup>15</sup>.

The results given by ultrasonography in diagnosis of acute appendicitis improve when the procedure is performed through graded compression technique, a technique endorsed by Ramachandran et al.<sup>16</sup> and Zielke et al<sup>17</sup>. With this technique, we found some findings that were highly supportive for the diagnosis of acute appendicitis. These findings were non-compressibility (83%), appendicular tube (55%), appendicolith (13%), omental thickening (80.5%), surrounding free fluid (63.8%), and the probe tenderness (91.7%). Borushok et al.<sup>18</sup> also worked on the sensitivity of ultrasonography in the diagnosis of acute appendicitis. His findings showed results similar to our findings. He found non-compressibility in 85%, appendicular tube in

60%, appendicolith in 69%, surrounding free fluid in 42%, and probe tenderness in 93% patients. The accuracy rate for Borushok et al. was 93% in comparison to our accuracy rate of 80%.

Ultrasonography has gained widespread acceptance as a reliable, highly accurate, and highly sensitive modality in evaluation of patients with acute appendicitis. It may clearly outline those patients who require surgery or other forms of intervention, as it can provide rapid and effective diagnostic information to guide appropriate clinical management. The usage of ultrasonography in examination is very useful to detect unclear clinical diagnosis of acute appendicitis in most patients especially females. In experienced hands, graded compression sonography has more than 80% accuracy for diagnosing acute appendicitis. It is suggested that all the patients with pain in the right lower quadrant of the abdomen must be evaluated by ultrasonography so as to decrease the rate of negative appendectomies.

## CONCLUSION

Ultrasonography, with a diagnostic accuracy of 80% was found effective in the diagnosis of acute appendicitis, and recommended as a screening tool in suspected cases of acute appendicitis.

## CONFLICT OF INTEREST

This study has no conflict of interest to declare by any author.

## REFERENCES

- O'Connell PR. The vermiform appendix. In: Williams NS, Bulstrode CJK, O'Connell PR. (eds.) Bailey & Love's Short Practice of Surgery, 26th ed. Florida (FL): Taylor & Francis Group; 2013. p. 1199-214.
- Wong SW, Haxhimolla H, Grieve DA, Fisher R, Keogh G. Insurance and the risk of ruptured appendix in the adult. *Aust N Z J Surg* 1999; 69: 31-3.
- Javidi Parsijani P, Pourhabibi Zarandi N, Paydar S, Abbasi HR, Bolandparvaz S. Accuracy of Ultrasonography in Diagnosing Acute Appendicitis. *Bull Emerg Trauma* 2013; 1: 158-63.
- Kalan M, Talbot D, Cunliffe WJ, Rich AJ. Evaluation of the modified Alvarado score in the diagnosis of acute appendicitis: a prospective study. *Ann R Coll Surg Engl* 1994; 76: 418-9.
- Jan H, Khan J. Evaluation of modified Alvarado score in the diagnosis of acute appendicitis. *Pak J Surg* 2007; 23: 248-50.
- Malik KA, Sheikh MR. Role of modified Alvarado score in acute appendicitis. *Pak J Surg* 2007; 23: 251-4.
- Nasiri S, Mohebbi F, Sodagari N, Hedayat A. Diagnostic values of ultrasound and the Modified Alvarado Scoring System in acute appendicitis. *Int J Emerg Med* 2012; 5: 26.
- Gujar N, Mudhol S, Choudhari RK, Sachin SD. Determination of Sensitivity and Specificity of Modified Alvarado Score and Ultrasonography in Patients with Acute Appendicitis. *J Krishna Inst Med Sci Uni* 2015; 4: 89-99.
- Maher MM, Dixon AK. Abdominal Imaging. In: Adam A, Dixon AK, Gillard JH, Schaefer-Prokop C, Grainger RG, Allison DJ, et al. (eds.) Grainger & Allison's Diagnostic Radiology, 6th edition. London: Elsevier Limited; 2015. p. 591-1034.
- Puylart JB. Acute appendicitis: US evaluation using graded compression. *Radiology* 1986; 158: 355-60.
- Garcia Peña BM, Mandl KD, Kraus SJ, Fischer AC, Fleisher GR, Lund DP, et al. Ultrasonography and limited computed tomography in the diagnosis and management of appendicitis in children. *JAMA* 1999; 282: 1041-6.
- Ceres L, Alonso I, López P, Parra G, Echeverry J. Ultrasound study of acute appendicitis in children with emphasis upon the diagnosis of retrocecal appendicitis. *Pediatr Radiol* 1990; 20: 258-61.
- Hussain S, Rahman A, Abbasi T, Aziz T. Diagnostic accuracy of ultrasonography in acute appendicitis. *J Ayub Med Coll Abbottabad* 2014; 26: 12-7.
- Arooj S, Haq A, Amin Z. The specificity and sensitivity of ultrasonography in the diagnosis of acute right lower quadrant pain in women of child bearing age. *J Pak Med Assoc* 2015; 65: 933-6.
- Alia N, Ahmad I, Hayat A, Amir MS, Omar B, Ikram S. Accuracy of gray scale ultrasound in diagnosis of acute appendicitis. *J Univ Med Dent Coll* 2013; 4: 56-61.
- Ramachandran P, Siviti CJ, Newman KD, Schwartz MZ. Ultrasonography as an adjunct in the diagnosis of acute appendicitis: A four-year experience. *J Pediatr Surg* 1996; 31: 164-7.
- Zielke A, Hasse C, Sitter H, Rothmund M. Influence of ultrasound on clinical decision making in acute appendicitis: a prospective study. *Eur J Surg* 1998; 164: 201-9.
- Borushok KF, Jeffrey RB Jr, Laing FC, Townsend RR. Sonographic diagnosis of perforation in patients with acute appendicitis. *AJR Am J Roentgenol* 1990; 154: 275-8.