

ACCURACY OF ULTRASONOGRAPHY IN DIAGNOSIS OF ACUTE APPENDICITIS; RESULTS OF A CROSS-SECTIONAL SURVEY AT TWO CENTRES

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ABSTRACT

Objective: To determine the accuracy of ultrasonography in diagnosing acute appendicitis (AA) by taking histopathology as gold standard.

Study Design: A cross-sectional validation study.

Place and Duration of Study: Departments of surgery and radiology, Combined Military Hospitals of Multan and Quetta, from Apr 2014 to Apr 2016.

Material and Methods: Ultrasonography of 200 consecutive patients fulfilling the diagnostic criteria on Modified Alvarado Scoring System for the clinical diagnosis of AA was done and the results were entered in proformas. Each patient underwent appendectomy and appendices in all cases were sent for histopathological examination. Sensitivity, specificity, positive predictive value (PPV), negative predictive value (NPV), and accuracy were calculated through Med Calc.

Results: Out of 200 patients, 132 were males and 68 were females. The most common age group was 11-30 years. The sensitivity of ultrasonography for AA was 61.43%, with a specificity of 76.67%, PPV of 86%, NPV of 46%, and an accuracy rate of 66%.

Conclusion: With sensitivity, specificity, and accuracy rate of 61.4%, 76.7%, and 66% respectively, ultrasonography is justified as an appropriate diagnostic tool in suspected cases of AA to avoid undue surgical interventions.

Keywords: Acute appendicitis, Accuracy, Appendectomy, Sensitivity, Specificity, Ultrasonography.

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INTRODUCTION

Acute appendicitis (AA) is one of the commonest surgical emergencies¹. Approximately 7% of the population will suffer from AA during their lifetime², with the peak incidence occurring between the ages of 10 and 30 years³. Therefore, much effort has been directed toward early diagnosis and intervention. Diagnosis of AA is mainly clinical but a long list of conditions mimicking this clinical scenario has created a lot of diagnostic confusion, resulting in negative appendectomy rate that once approached 23% in 1990 and 19% in 2008^{4,5}.

At the extremes of age (below 5 and above 60 years), it is more likely that appendicitis will present with atypical history and clinical findings

and hence diagnosis is often difficult and may be delayed. Pain in the lower abdomen and right iliac fossa (RIF) is a common indication of emergency hospital admission with a suspicion of AA⁶. Although early clinical evaluation and surgical intervention are mandatory in AA, at times, conventional diagnostic approaches such as history taking, physical examination, and routine laboratory tests are inconclusive^{7,8}. Hence, imaging tests are commonly used to improve diagnostic accuracy^{4,5,9} and to rule out conditions mimicking appendicitis.

Abdominal ultrasonography is one of the important diagnostic tools in AA. It is now increasingly advocated that all patients with a suspicion of AA should routinely undergo abdominal ultrasonography performed by an experienced radiologist to confirm the diagnosis and prevent negative appendectomy⁹. Numerous prospective clinical trials have reported an

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accuracy of 76.3% to 96%, sensitivity of 44% to 100%, and specificity of 47% to 99% of ultrasonography in the diagnosis of AA⁹⁻¹⁴.

Keeping in view the common nature of this problem, a need was felt to carry out a study to determine accuracy of ultrasonography in the diagnosis of AA. The results of this study would guide us to formulate a policy, either to request or not, an abdominal ultrasonography in cases of clinically suspected AA.

PATIENTS AND METHODS

This was a cross-sectional validation study, carried out from Apr 2014 to Apr 2016, at the surgery and radiology departments of Combined Military Hospitals of Multan and Quetta, which are tertiary care hospitals, draining serving and retired personnel of armed forces and their

performing physical examination, and complete blood count evaluation.

The patients scoring 5 or higher on the Modified Alvarado Scoring System for the clinical diagnosis of AA¹⁷ were consecutively sampled and admitted in the indoor departments. All cases underwent ultrasonographic evaluation by a senior consultant radiologist using ultra-sonography machine "Mindray DP-50" (Shenzen Mindray Bio-medical Electronics Co., Shenzen, China). The ultrasonographic criteria for the diagnoses of AA given by Maher and Dixon¹⁸ was followed. The results were entered in structured proformas. All patients with clinical appendicitis underwent appendectomy. The removed appendix was sent for histopathological examination in all cases. The histopathological reports were collected,

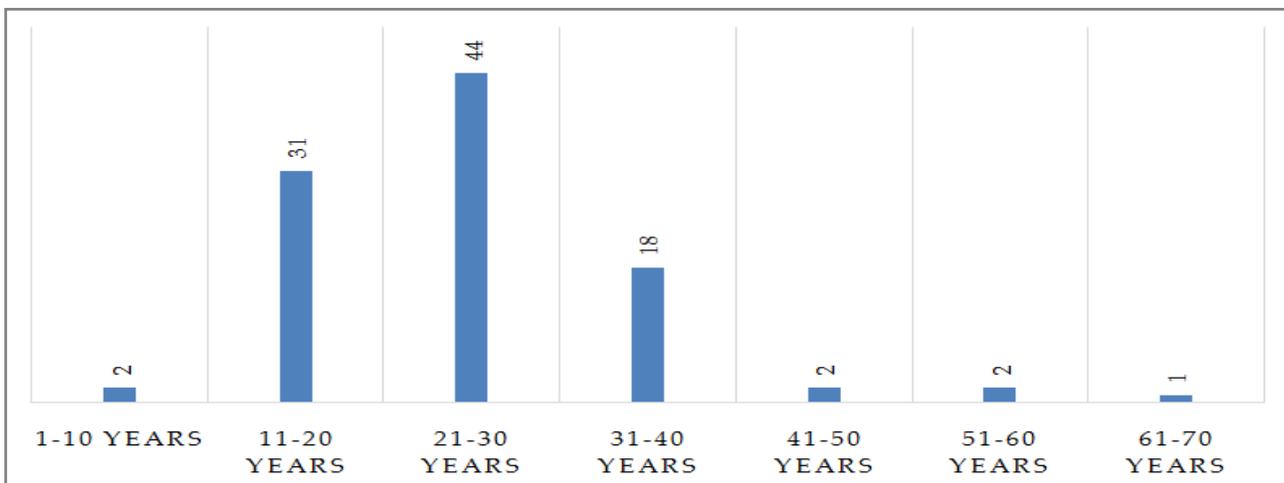


Figure-1: Age distribution of the sample.

families and civilian patients in their surrounding areas, representing all ethnic groups. A sample size of 183 was calculated using a sample size calculator¹⁵, while using a sensitivity of 84%⁹, specificity of 67%⁹, expected prevalence of 29%¹⁶, desired precision of 0.1, and confidence level of 95%. The different study variables were age, gender, and ultrasonographic and histopathological diagnosis of each patient. All patients, presenting in the surgical outpatient department or the emergency department of above named hospitals with complaints of right lower quadrant abdominal pain were evaluated by taking history,

documented in the respective proformas, and compared with the ultrasonographic findings of the patients.

At the end, the data were analyzed using the Statistical Package for Social sciences (SPSS) version 20.0 (IBM Corp., Armonk, NY, USA) and Med Calc (MedCalc Software, Ostend, Belgium). Descriptive data were presented as frequencies and percentages for age, gender, various symptoms and signs, and ultrasonographic and histopathological findings. Sensitivity analysis was performed to assess

sensitivity, specificity, positive predictive value (PPV), and negative predictive value (NPV) of ultrasonography taking histopathological diagnosis as gold standard.

RESULTS

A total of 200 patients were studied. There were 132 (66%) males and 68 (34%) females making a male to female ratio of 2:1. The mean age was 25.7 ± 13.4 years with a range of 8-70 years. The most common age group was 11-30 years (fig-1). Clinically, the pain in RIF was present in all patients. In 52% (n=104), the pain started in the RIF while in 48% (n=96) patients, the pain started in the umbilical or epigastric region and latter migrated to the RIF. Vomiting was present in 61% (n=122), anorexia in 70% (n=140), and fever was present in 22% (n=44) patients. Total leucocyte count was raised in 45% (n=90) patients.

Sonographically, 100 (50%) patients had AA (74 male and 26 female). Out of them, 86 had histopathologically proven AA while 14 were having normal appendix. In the rest 100 (50%) patients, a normal appendix was commented by the radiologist in 56 patients and appendix was not visualized in 44 patients. Histopathologically, 140 (70%) patients had positive histopathology. Thus, 43% (n=86) patients had true positive results, 23% (n=46) patients had true negative results, 7% (n=14) patients had false positive results while 27% (n=54) patients had false negative results making an overall sensitivity of 61.43%, specificity of 76.67%, PPV of 86%, NPV of 46%, and an accuracy rate of 66%.

Out of 132 males, 50% (n=66) patients had true positive results, 21.21% (n=28) patients had true negative results, 6.06% (n=8) patients had false positive results, while 22.72% (n=30) patients had false negative results. Out of 68 females, 29.41% (n=20) had true positive results, 26.47% (n=18) patients had true negative results, 8.82% (n= 6) patients had false positive results while 35.29%(n=24) patients had false negative results. The receiver operating characteristic

curve interpreting sensitivity and specificity levels has been presented as fig-2.

DISCUSSION

As it is said that appendicitis is the disease of younger age, our study supports this view. In this series, the commonest age group was 11-30 years (75%). In a comparative international study, the commonest age-group (90%) was 10-30 years³. According to Amir and Shami, 1944. Eight percent cases of AA were in their 2nd decade and 30% cases were in the 3rd decade with a gradual decrease in incidence with age. *Ihsan et al*⁹ in a series of 100 patients, had maximum patients

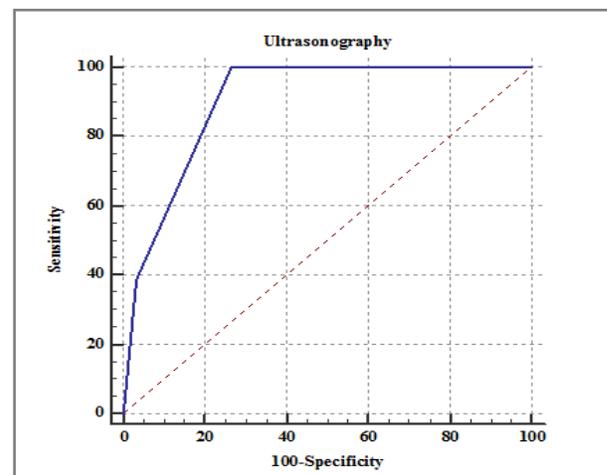


Figure-2: Receiver operating characteristic curve interpreting sensitivity and specificity levels among patients.

between 15-25 years while *Parsijani et al*²⁰ reported maximum number of patients (57%) between 5 and 16 years of age in a study comprising 377 patients.

Pain was the most common presenting symptom in our study and was present in all patients of our study. This is similar to the study of *Adesunkanmi et al*²¹ who reported lower abdominal pain in all cases of AA. In our study, the majority of patients (52%) had pain starting in the RIF while in 48% patients, pain started in the umbilical or epigastric region and latter migrated to the RIF. In the literature, the migration or shifting of pain to RIF is variable and is found in 30-64% of the patients²². *Lee et al*²³ in a large series

of 766 patients emphasized migratory pain with PPV of 91% which was more than that of raised leucocyte count, computerized tomography scan, and ultrasonography. Another study showed that there was no difference in the frequency of migration among patients with or without appendicitis²⁴. So, when migration or shifting to RIF is present, appendicitis is likely, while absence of migration does not indicate a normal appendix.

Anorexia was the other most common symptom after pain in this study. It was found in 70% of the patients. This figure, more or less, compares with the literature. According to two studies^{19,21} anorexia was present in 82% and

specificity, as quite a number of patients (30-50%) with normal appendix also have this symptom¹⁹. In a comparative study by Chaudhary *et al*²⁶, right lower quadrant pain was present in more than 95% of cases with AA, and in more than 65% of cases, there was history of nausea, vomiting, and anorexia.

The overall accuracy, sensitivity, and specificity of the ultrasonographic examination in this study was 66%, 61.43%, and 76.67% respectively. These results can be compared to previous studies carried out in Pakistan. A review of the studies has been shown in table. Out of 13 references^{9-12,27-35} (table) identified through electronic searches and including the

Table: Summary sensitivity and specificity of Pakistani references identified through electronic searches.

S No.	Authors	Year of publication	Sensitivity (%)	Specificity (%)
1.	Afzal et al ²⁵	1997	38.88	83.8
2.	Qureshi et al ²⁶	2001	88.8	83.9
3.	Ahmad et al ²⁷	2003	71.8	62.5
4.	Saeed et al ²⁸	2009	85	86
5.	Yousaf et al ²⁹	2011	68	88
6.	Hussain et al ³⁰	2012	31	75
7.	Ahmed et al ³¹	2012	94	68.18
8.	Abbasi et al ³²	2012	44	89.3
9.	Alia et al ¹²	2013	96.72	89.74
10.	Hussain et al ¹⁰	2014	88	92
11.	Qureshi et al ³³	2014	91.5	87.5
12.	Arooj et al ¹¹	2015	94	84
13.	Ihsan et al ⁹	2017	84	67
14.	Present study	2018	61.43	76.67

77.7% of the sampled patients respectively. In one textbook, it was considered the characteristic symptom of AA, positive in more than 90% cases²⁵. Thus, anorexia is a reliable indicator of AA, and one should deeply inquire about this symptom.

In our study, 61% patients had one or two episodes of vomiting, by and large, in the early stage of disease. This complaint always followed the pain. The relevant literature reveals that 51-69% of patients with appendicitis have one or more episodes of vomiting^{19,22}. It seems that this symptom has high sensitivity rate but less

present study, the summary sensitivity and specificity of ultrasonography for diagnosis of AA were 74.1% (95% CI 61.2-86.9%) and 81% (95% CI 75.5-86.4%), respectively. The sensitivity of ultrasonography is less than the specificity because of the large number of false negatives mainly due to poor tolerance by the patient, obesity, presence of gas and unusual location of the appendix³⁶. The higher specificity of ultrasonographic examination reported by Pakistani studies endorses this evaluation as a useful tool for the differential diagnosis of associated pathology such as mesenteric lymphadenitis or

gynecological disorders in suspected cases of AA³⁷. It is suggested that all patients with pain in the right lower quadrant of the abdomen must be evaluated by ultrasonography so as to decrease the rate of negative appendicectomies.

The ultrasonographic examination as a sole diagnostic investigation for AA is debatable. Many studies suggest combining ultrasonography with Alvarado score that is a quick and inexpensive diagnostic tool³⁸⁻⁴¹, though, when used alone, has a high negative appendectomy rate especially when the scores are less than eight³⁸. The combined accuracy of both diagnostic tools is considered a reliable evidence to decide surgical intervention without going for other investigations like computerized tomographic scan of the abdomen especially in children⁴¹. Based on results of these studies, we also suggest linking results of both these non-invasive and cheap evaluation tools with each other to reduce the frequency of unnecessary surgical interventions.

CONCLUSION

With sensitivity, specificity, and accuracy rate of 61.4%, 76.7%, and 66% respectively, ultrasonography is justified as an appropriate diagnostic tool in suspected cases of AA to avoid undue surgical interventions.

CONFLICT OF INTEREST

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

REFERENCES

1. Douglas CD, Macpherson NE, Davidson PM, Gani JS. Randomized controlled trial of ultrasonography in diagnosis of acute appendicitis, incorporating the Alvarado score. *BMJ* 2000; 321(7266): 919-22.
2. Debnath J, Ram S, Balani S, Chakraborty I, Gupta PD, Bindal RK, et al. Ultrasonography in patients with suspected acute appendicitis. *Med J Armed Forces India* 2005; 61(3): 249-52.
3. Vijayasree V, Sunil CSPV, Noel S, Rao TS. Histopathological spectrum of appendicular lesions and correlation with age and sex incidence: A retrospective study. *Med Pulse Int J Pathol* 2017; 4(1): 16-20.
4. Raja AS, Wright C, Sodickson AD, Zane RD, Schiff GD, Hanson R, et al. Negative appendectomy rate in the era of CT: An 18-year perspective. *Radiology* 2010; 256(2): 460-5.
5. Boonstra PA, van Veen RN, Stockmann HB. Less negative appendectomies due to imaging in patients with suspected appendicitis. *Surg Endosc* 2015; 29(8): 2365-70.
6. Ali N, Sadiq N, Bacha J, Hadi G. Correlation of clinical and histological diagnosis of acute appendicitis. *J Postgrad Med Inst* 2003; 17(2): 254-7.
7. Poortman P, Lohle PN, Schoemaker CM, Oostvogel HJ, Teepe HJ, Zwinderman KA, et al. Comparison of CT and sonography in the diagnosis of acute appendicitis: A blinded prospective study. *AJR Am J Roentgenol* 2003; 181(5): 1355-9.
8. Torbati SS, Guss DA. Impact of helical computed tomography on the outcomes of emergency department patients with suspected appendicitis. *Acad Emerg Med* 2003; 10(8): 823-9.
9. Ihsan HR, Ayaz SB, Farooq M, Saeed M, Aslam S. Sensitivity and specificity of ultrasonography in cases of suspected acute appendicitis. Results of a cross-sectional survey. *Pak Armed Forces Med J* 2017; 67(Suppl-3): S287-91.
10. Hussain S, Rahman A, Abbasi T, Aziz T. Diagnostic accuracy of ultrasonography in acute appendicitis. *J Ayub Med Coll Abbottabad* 2014; 26(1): 12-7.
11. 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(9): 933-6.
12. 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(1): 56-61.
13. Pinto F, Pinto A, Russo A, Coppolino F, Bracale R, Fonio P, et al. Accuracy of ultrasonography in the diagnosis of acute appendicitis in adult patients: review of the literature. *Crit Ultrasound J* 2013; 5(Suppl-1): S2.
14. Thirumoorthi AS, Fefferman NR, Ginsburg HB, Kuenzler KA, Tomita SS. Managing radiation exposure in children re-examining the role of ultrasound in the diagnosis of appendicitis. *J Pediatr Surg* 2012; 47(12): 2268-72.
15. Naing L. Sample size calculation for sensitivity and specificity studies [Internet]. Mohd Ayub Sadiq School of Dental Sciences, Universiti Sans Malaysia; 2004. [cited 2018]. Available from: www.kck.usm.my/ppsg/samplesize_forsensitivity_specificitystudiesLinNaing.xls.
16. Khan M, Naz S, Zarin M, Rooh-ul-Muqim SM. Epidemiological observations on appendicitis in Peshawar, Pakistan. *Pak J Surg* 2012; 28(1): 30-3.
17. 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.
18. 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; 591-1034.
19. Amir M, Shami IH. Analysis of early appendicectomies for suspected acute appendicitis. A prospective study. *J Surg PIMS* 1992; 3: 25-8.
20. Parsijani PJ, Zarandi NP, Paydar S, Abbasi HR, Bolandparvaz S. Accuracy of ultrasonography in diagnosing acute appendicitis. *Bull Emerg Trauma* 2013; 1(4): 158-163.
21. Adesunkanmi AR. Acute appendicitis: a prospective study of 54 cases. *West Afr J Med* 1993; 12(4): 197-200.
22. Wazir MA, Anwar AR, Zarin M. Acute appendicitis, a retrospective study. *J Postgrad Med Inst* 1998; 12: 33-6.
23. Lee SL, Walsh AJ, Ho HS. Computed tomography and ultrasonography do not improve and may delay the diagnosis and treatment of acute appendicitis. *Arch Surg* 2001; 136(5): 556-62.
24. Barber MD, McLaren J, Rainey JB. Recurrent appendicitis. *Br J Surg* 1997; 84(1): 110-2.
25. Schwartz SI, Shires GT, Spencer FC. Eds. Appendix. In: *Principles of Surgery* 7th Ed. 1999. McGraw-Hill NY. 1383-94.

26. Chaudhary IA, Ajmal RM, Mumtaz B, Maqsood R. Cough Sign: Reliability in the diagnosis of acute appendicitis. *J Coll Physicians Surg Pak* 2002; 12(9): 546-8.
 27. Afzal M, Ahmed MS, Javed M, Rafi M, Siddiqui MAJ. Ultrasonography can improve diagnostic accuracy in equivocal cases of Appendicitis. *Biomedica* 1997; 13(1): 46-50.
 28. Qureshi IA, Tarin BA, Shafiq M. Role of Ultrasonography in clinically suspected cases of Acute Appendicitis. *Pak Armed Forces Med J* 2001; 51(2): 90-3.
 29. Ahmad AN, Fatima N, Hussain RA, Qadir SNR. Comparative evaluation of the role of Sonography in diagnosis of Acute Appendicitis versus Surgeon's clinical impression *Ann King Edward Med Coll* 2003; 9(1): 27-8.
 30. Saeed K, Mehboob F, Azam V. Role of abdominal sonography in the diagnosis of acute appendicitis. *Rawal Med J* 2009; 34(2): 138-40.
 31. Yousaf KR, Atiq S, Bilal S, Nisar MS, Ismail M, Yousaf K, et al. Emergency based ultrasound of clinically suspected acute appendicitis with low frequency curvilinear transducer and its association with surgical outcome. *Pak J Med Health Sci* 2011; 5(2): 361-4.
 32. Hussain N, Zaman S, Malik NA, Khan JS, Khan MM. Sensitivity and specificity of investigations for the diagnosis of acute appendicitis and their correlation with histopathology findings. *J Rawal Med Coll* 2012; 16(2): 129-31.
 33. Ahmed F, Tahir M, Uddin QT, Khan EA, Tahir NB, Sardar S, et al. Ultrasonography: A good aid to the clinical diagnosis of acute appendicitis. *Khyber Med Univ J* 2012; 4(4): 165-69.
 34. Abbasi SA, Mishwani AH. Diagnostic accuracy of total leucocyte count and ultrasound in the diagnosis of acute appendicitis. *J Rawal Med Coll* 2012; 16(2): 147-9.
 35. Qureshi A, Sultan N, Aziz A, Sheikh B. Sensitivity of ultrasonography in the diagnosis of acute appendicitis as compared to clinical, per operative and histopathologic findings. *Pak J Surg* 2014; 30(3): 205-10.
 36. Galindo Gallego M, Fadrique B, Nieto MA, Calleja S, Fernández-Aceñero MJ, Ais G, et al. Evaluation of ultrasonography and clinical diagnostic scoring in suspected appendicitis. *Br J Surg* 1988; 85(1): 37-40.
 37. Gaensler EH, Jeffrey RB, Laing FC, Townsend RR. Sonography in patients with suspected acute appendicitis: Value in establishing alternative diagnosis. *AJR Am J Roentgenol* 1989; 152(1): 49-51.
 38. Samir M, Hefzy M, Gaber M, Moghazy K. Added value of graded compression ultrasound to the Alvarado score in cases of right iliac fossa pain. *Afr J Emerg Med* 2016; 6(3): 138-43.
 39. Gupta M, Virdi VS, Agnihotri L, Mandial V. Evaluation of modified alvarado score and ultrasonography for the diagnosis of acute appendicitis. *Int J Sci Res* 2016; 5(3): 2166-8.
 40. 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(1): 26.
 41. Blitman NM, Anwar M, Brady KB, Taragin BH, Freeman K. Value Of Focused Appendicitis Ultrasound And Alvarado Score In Predicting Appendicitis In Children: can we reduce the use of CT? *AJR Am J Roentgenol* 2015; 204(6): W707-12.
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