



## Role of Ultrasonography in diagnosis of Acute Appendicitis: A Study at a Tertiary Care Hospital

### KEYWORDS

appendicitis, ultrasonography, specificity.

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### ABSTRACT

*Acute appendicitis remains the leading cause of abdominal pain and the most common indication for emergency operation.*

*Prompt diagnosis of acute appendicitis is rewarded by a marked decrease in morbidity and negative laparotomies. Ultrasound is a widely used initial radiological investigation for the diagnosis of acute appendicitis, its utilization remains controversial and the decision for surgical intervention is still primarily based on precise clinical criteria. This study is done to establish the role of ultrasound in diagnosis of acute appendicitis. Diagnostic role of ultrasound was evaluated by calculating sensitivity, specificity, positive predictive value, negative predictive value and overall diagnostic accuracy. Total of 132 patients were included in the study during the study period of one year, i.e., September 2015 to September 2016. Those cases with alternate diagnosis were followed up and proved with other means of investigation. The sensitivity, specificity, positive predictive value and negative predictive value of ultrasound scanning with reference to histopathological confirmation was 95.58 %, 89.47 %, 98.18% and 77.27% respectively.*

### 1. Introduction

Acute appendicitis represents one of the most common causes of abdominal pain and appendectomy is the most frequent emergent surgery performed worldwide [1, 2]. The major contributing factors for high negative appendectomy rates are non-specificity of clinical findings, lack of readily available technique allowing direct visualization of appendix and identification of specific diagnostic features of acute appendicitis. Lack of early diagnosis results in appendicular perforation, chronicity, appendicular mass or abscess, sepsis and death. Appendiceal and other rupture incidents accounts for 17-40% morbidity, perforation rate being higher in the elderly and very young [4,9]. There is approximately 15-35% negative laparotomy rate with significant chances of morbidity especially the younger women (upto 45%). This is due to high prevalence of common obstetrical and gynecological disorders notably the pelvic inflammatory diseases [9,3,8].

Ultrasound (USG) is a valuable tool currently used in clinical practice as this is noninvasive, repeatable, avoids radiation and less expensive. It was first introduced by Puylaert in 1986, who described the "graded compression" technique apt to visualize the inflamed appendix [7]; where a linear high-frequency transducer is placed on the right lower quadrant and pressure is applied gradually while imaging, displacing overlying gas-filled loops of bowel. USG findings suggestive of appendicitis include, a thickened wall, aperistaltic non-compressible lumen, outer appendiceal diameter greater than 6 mm [17], absence of gas in the lumen, appendicoliths, echogenic inflammatory peri appendiceal fat change, and increased blood flow in the appendiceal wall.

If compared to other diagnostic tests, USG is inferior to CT as to sensitivity; due to its low negative predictive value for appendicitis, it may not be as useful for excluding appendicitis. More recently, color and power Doppler examination of the appendix have proven to be a useful adjunct to improve the sensitivity by demonstrating increased flow in an inflamed appendix [5,21]. The quality of the ultrasound examination is operator dependent.

### 2. Aims & objectives

To determine the specificity, sensitivity, positive predictive value, negative predictive value and accuracy of USG in clinically suspected acute appendicitis.

### 3. Materials and methods:

A structured pre-prepared case proforma was used to enter the complete history, clinical examination findings, investigations-hematological and ultrasound, per-operative findings and histopathological report. This study included 132 cases of clinically suspected acute appendicitis, selected on non-probability convenience sampling technique and conducted a cross-sectional validation study at ASRAM Eluru. These cases were subjected to imaging with Philips HD 11 XE ultrasound machine with multi-frequency linear array transducer (7.5MHz-10.0MHz) and curvilinear transducer (3.5MHz-7.0MHz), using graded compression technique.

In women, a USG study of abdomen and pelvis was acquired with 3.5MHz-7.0MHz curvilinear transducer with the patient's bladder partially filled. By using a linear array transducer, the sonographic plane was perpendicular to the table, the special flat T-shape enabled the examiner to exert gentle compression with the transducer using both hands in the same way as when palpating the abdomen. Diagnostic accuracy of USG was established using histopathology of the removed appendix as gold standard.

### Criteria for evaluation:

- Outer diameter of appendix less than 6mm or non-visualization of appendix was recorded as a negative result.
- Inflamed appendix and increased blood flow in appendiceal wall or peri appendiceal abscess were considered positive result.
- A thickened wall, aperistaltic non-compressible lumen, absence of gas in the lumen and appendicoliths was considered as positive result.
- Histopathological examination after appendectomy formed the basis for definitive diagnosis.
- In patients not undergoing surgery diagnosis was verified by CT scan and evaluation by ALVARADO score, various hematological investigations, diagnostic laparoscopy, and follow up observations.

### Inclusion Criteria

- Patients of age above 6 years and below 80 years, with clinically suspected acute appendicitis.

### Exclusion Criteria

- Patients who did not consent for the study
- Patients who could not be followed up after conservative management
- Moribund patients who were not fit for surgery.
- Patients with Pregnancy.

4. Results

Out of 132 patients included in the study, 117 patients underwent surgery and ultrasound findings were correlated with histopathology report as gold standard, as shown in

Table 1. Results of USG Studies in Diagnosis of Acute Appendicitis

US Finding	HPE finding*		
	Yes	No	Total
Yes	(TP)108	(FP)2	110
No	(FN)5	(TN)17	22
	113	19	132

\*True negatives and false negatives that were proven with other means of evaluation are also included in the same table for statistical convenience

Out of 132 cases 117 cases underwent surgery. Among those 117 cases only 108 cases were proven to have acute appendicitis, which were also diagnosed as acute appendicitis by USG (true positives). The remaining 9 cases that were operated based on clinical and hematological evaluation, in 2 cases USG was positive but histopathologically appendicitis was absent and in remaining 5 cases USG was negative but histopathology showed positive report, and remaining 2 cases were negative both ultrasonologically and histopathologically(true negatives). Diagnostic role of ultrasound was evaluated by calculating sensitivity, specificity, positive predictive value, negative predictive value and overall diagnostic accuracy using standard formulae and values obtained are shown in

Table 2. Diagnostic Role of USG

Evaluation of USG	Values (%)
Sensitivity	95.58
Specificity	89.47
Positive Predictive Value	98.18
Negative Predictive Value	77.27
Diagnostic Accuracy	94.69

The following features formed the basis of ultrasonological diagnosis among 113 cases of histopathologically proven acute appendicitis, with associated other features of inflammation, described in

Table 3. USG Findings in Histopathologically Proven Appendicitis

USG Findings	No. of Cases	Percentage
Visualization of Appendix	108	95.5
Target Sign on Transverse Scan	104	92.03
Sonographic Mc Burney's Tenderness	110	97.34
Appendicolith	10	8.84
Free Fluid in Right Iliac Fossa	94	83.18
Echogenic Surrounding Mesentery	80	70.79
Loss of Submucosal Integrity	26	23

Figure 1. USG showing target sign of inflamed appendix

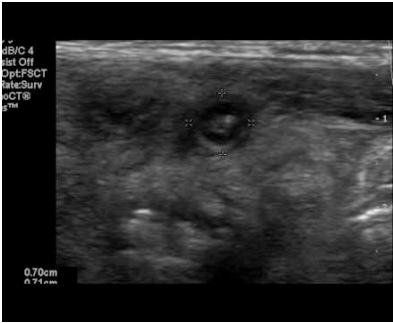


Figure 2. USG showing irregular wall thickening and mucosal irregularity in inflamed appendix. Diameter is approx. 8.4 mm



5. Discussion

Our study was a prospective study of 132 patients clinically suspected as acute appendicitis. After a detailed history and clinical examination, ultrasound examination of the right iliac fossa using graded compression technique using high resolution, high frequency probes (linear array 7.5-10MHz and curvilinear array 3.5-7.0MHz) was done.

Age prevalence showed less than 4.8 % of patients in the age group of 8-10 years and 11.9 % of patients above the age group of 50 years were affected. Males were more commonly affected than females, with a male:female ratio of 1.7:1. These results were comparable to the study done by Lewis et al who observed that less than 10% of patients were affected in the age group of 8-10 years and less than 10% of patients were affected in the age group of 50 years and above with male:female ratio of 2:1. Our study showed that highest number of acute appendicitis occurred in the age group of 8-20 years followed by age group of 21-30 years which is consistent with the findings shown by Addis et al that it is most common in 10 to 19 year old age group.

Symptoms

Patients presented with various symptoms among which 98% patients had periumbilical pain radiating to right iliac fossa or pain starting directly in right iliac fossa. No significant difference in duration of pain existed between acute appendicitis and other pathological conditions like renal/ureteric colic. Lewis et al noted pain abdomen in 99% of patients, which was localized to the right lower quadrant in 75% of patients and 10% to the periumbilical area. Anorexia was seen in 52.38 % cases. Nausea was seen in 69.04% cases where as vomiting was seen in 35.71 % of patients. Fever was seen in 38.9% of patients. Our findings are similar to the study done by Tauro LF et al in which 37 % patients had fever.

Signs

In the current study, tenderness in right iliac fossa was seen in 100% cases whereas rebound tenderness at Mc Burney's point was noted in 86% of patients which is like the finding noted by Tauro LF et al which showed 100% patients having right iliac fossa tenderness and 65 % patients having rebound tenderness at Mc Burney's point. Sohail et al. emphasized the same finding that scanning the point that the patient says hurts the most increases the detection rate of

appendicitis.

### Laboratory Investigations

Total white cell count was raised significantly in 88.09% of our patients. Significant neutrophilia was present in 71.42% of our patients. These results were comparable to the study done by Lewis et al. [9]. The results are also in accordance to study done by Kessler et al. [12] in which white blood cell count above 10,000/L had a sensitivity of 77% and specificity of 63%. In study done by Taura LF et al. [10] Leucocytosis was present in 75% of the cases and Neutrophilia in 86% of the cases. A study of 225 patients by Doraiswamy [13] showed leucocytosis in 42% and neutrophilia in 96% of the cases.

### Ultrasonography in the Diagnosis of Acute Appendicitis.

Out of the 132 cases of this study, 113 cases were proved to be acute appendicitis by histopathological examination. And 4 cases were proved to be negative on histopathology. Among the 132 cases, ultrasonography was positive in 110 cases. Among the operated USG positive cases of appendicitis, 108 cases were acute appendicitis on histopathological examination. Thus, 108 cases were taken as true positive cases. Two cases were negative for acute appendicitis on histopathological report and were taken as false positive case. Two cases diagnosed as false positive were probably mistaken for an ileal loop. Other 22 cases which were negative for acute appendicitis on ultrasound also underwent appendicectomy because of typical clinical picture and non-resolving pain in conservative management. Among these 22 cases, 5 were positive for acute appendicitis on histopathological examination. These 5 cases were taken as false negative cases. The remaining 9 cases were considered true negative. Eight cases in which alternating diagnosis was given like right renal calculus, right ureteric calculus and caecal malignancy were also taken as true negative cases. Hence, total number of true negative cases in our study was 17.

High-resolution real time sonography is non-invasive diagnostic modality which is readily available and enables direct visualization of an inflamed appendix or periappendiceal abscess. Extended sonography is also of value in patients without evidence of acute appendicitis. It can provide echo morphologic findings that may suggest an alternate diagnosis such as mesenteric adenitis, terminal ileitis, gynecologic disorders and urologic diseases as quoted by Geansler et al [14], Ooms et al [15] and Abu-youseff [6].

In our study US could visualize 108 appendices out of 132 cases who had clinical presentation of acute appendicitis, 113 cases had findings of appendicitis at surgery and HPE. John et al [16] could diagnose 70 out of 140 cases as acute appendicitis by USG.

Puylaert [7] et al did not demonstrate normal appendix by sonography. However recent reports where high frequency transducers were used did show normal appendix in a small percentage of cases (5 out of 250 cases) as reported by Jeffrey et al [17]. Similar findings were shown by Rioux et al [18]. More recently Lee et al [19] reported that with the use of additional operator dependant techniques, detection rates of normal and abnormal appendices have greatly increased. In our study we identified 5 normal appendices accounting for 3.78 % of the total number of cases. The normal appendix was compressible, less than 6mm in diameter and appeared ovoid in cross-section. In this case we confidently excluded the diagnosis of acute appendicitis. This finding was similar to that of Thomas Rettenbacher et al [20]. In 5 cases ultrasound was unable to detect appendix, either normal or abnormal. This was due to presence of guarding and rigidity, which hinders compression, non-visualization of normal appendix per se, presence of localized ileus and obesity.

In all cases of acute appendicitis, probe tenderness was present at the Mc Burney's point. The outer diameter of the appendix was greater than 6mm in all the 108 cases. It is similar to the criteria laid down by

Jeffrey et al [17] and reinforced by Thomas Rettenbacher et al [20]. The overall accuracy of sonography in the diagnosis of acute appendicitis in our study was 94.69 %.

In this study, sensitivity, specificity, positive predictive value and negative predictive value of ultrasound scanning with reference to histopathological confirmation was 95.58 % , 89.47 %, 98.18% and 77.27% respectively which showed that USG has a high specificity and sensitivity in diagnosing appendicitis.

The table below (Table 5) summarizes the results of the present study compared with the results of similar studies done in different parts of the world.

### False Negative Cases of Acute Appendicitis

As we can see by analyzing the table, the use of high frequency transducers increases the detection rates of appendix and decreases the false negative cases. Joshi et al [23] used a 10 MHz linear array probe along with 6.5MHz curvilinear array probe and results were impressive compared to Puylaert et al [7] who used 7.5 MHz linear array with 5 MHz curvilinear array transducer which gave a sensitivity of 89% and specificity of 100%.

False negativity also decreases as the operator gains experience, which is in accordance with Wade et al [24] who mentioned that the results would not be so impressive if the operator did not have enough experience.

### Factors Influencing False Negative Diagnosis of Acute Appendicitis

It is reported by Yacoe and Jeffrey [25] that one of the factors responsible for false negative diagnosis in acute appendicitis is retrocaecal position of the appendix and when caecum is filled with gas and feces where adequate compression is not possible. In our study out of 5 false-negative cases, 3 was retrocecal in position and proper evaluation by adequate compression was not possible due to gas distended cecum. In 2 cases appendicitis was missed, as the patients were obese.

### Conclusion

In acute appendicitis, if clinical signs and symptoms are combined with USG findings, the diagnostic accuracy is significantly increased. USG helps in identifying alternative causes of RIF pain thus excluding appendicular pathology. USG does not replace clinical diagnosis, but is a useful adjunct in the diagnosis of acute appendicitis. USG can be used as a valuable tool in diagnosing acute appendicitis despite sophisticated investigations like CT abdomen and laparoscopy; thus, reducing the cost of treatment and preventing negative laparotomies.

**Table 5.** Comparative Results in Different Studies

References	Sensitivity (%)	Specificity (%)	Positive predictive Value (%)	Negative predictive value (%)	Accuracy (%)
Present study	95.58	89.47	98.18	77.27	94.69
Joshi et. al	96	93	98	88	95
Rioux et al	93	94	86	98	94
Puylaert et al	89	100	-	-	-
Wolf et al	96	93	98	88	95.7
Rettenbacher et al	100	68	63	100	79
Kessler N et al	98	98	98	98	97
Baldisserotto et al	98.5	98.2	98	97	-
Chan et al	83	95	86	94	92
Lee et al	99	99	-	-	99
Tauro LF et al	91.37	88.09	91.37	88.09	90

## References

1. Reginelli A, Pezzullo MG, Scaglione M, Scialpi M, Brunese L, Grassi R: Gastrointestinal disorders in elderly patients. *Radiol Clin North Am* 2008; 46(4):755-71.
2. Macarini L, Stoppino LP, Centola A, Muscarella S, Fortunato F, Coppolino F, Della Valle N, Ierardi V, Milillo P, Vinci R: Assessment of activity of Crohn's disease of the ileum and large bowel: proposal for a new multiparameter MR enterography score. *Radiol Med* 2013; 118(2):181-195.
3. Addiss DG, Shaffer N, Fowler BS, Tauxe RV. The epidemiology of appendicitis and appendectomy in the United States. *Am J Epidemiology* 1990;132:910-25.
4. Seymour I Schwartz, Harold Ellis. *Maingots abdominal operations Vol. 1.* 1255-1281.
5. Quillin SP, Siegel MJ: Appendicitis: efficacy of color Doppler sonography. *Radiology* 1994; 191:557-560.
6. Abu-Yousef MM. *Ultrasonography Of Right Lower Quadrant.* *Ultrasound Quarterly* 2001;17(4):221-5.
7. Puylaert J. Acute appendicitis: US evaluation using graded compression. *Radiology* 1986; 158:355-60.
8. Berry J, Malt R. Appendicitis near its centenary. *Ann Surg.* 1984; 200:567-575.
9. Lewis FB, Holcroft JW, Boey J, Dumphry E. A Critical Review Of Diagnosis And Treatment In 1000 Cases. *Arch Of Sur.* 1975; 110:677-84.
10. Tauri LF, Premanand T S, Aithala P S, George C, Suresh H B, Acharya D, John P. Ultrasonography Is Still A Useful Diagnostic Tool In Acute Appendicitis, *Journal of Clinical and Diagnostic Research* 2009 Oct; 3:1731-36 Wilson, Stephine R. Gastrointestinal tract. In: Carol M. Rumack, Stephine R Wilson, J. William charbneau [ed]; *Diagnostic Ultrasound*, 2nd ed; Missouri, Mosby; 1998; Volume 1:303-6.
11. Sohail et al. Doptaus – a simple criterion for improving sonographic diagnosis of acute appendicitis *J Pak Med Assoc* 2009; 59: 79-82.
12. Nicolas Kessler, MD Catherine Cyteval, MD, PhD Benoit Gallix, MD, PhD Alvin Lesnik, MD Paul-Marie Blayac, MD Joseph Pujol, MD Jean-Michel Bruel, MD Patrice Taourel, MD, PhD Appendicitis: evaluation of sensitivity, specificity, and predictive values of US, Doppler US and laboratory findings *Radiology* 2004; 230:472-8.
13. Doraiswamy N.V. Leucocyte counts in the diagnosis and prognosis of acute appendicitis in children. *Br J Surg.* 1979; 66:782.
14. Gaensler R, Erik HLL, Brooke Jeffrey, Jr, Faye C Laing, Ronald R Townsend; *Sonography In Patients With Suspected Acute Appendicitis: value in establishing alternative diagnoses; AJR* 1989; 152:49-51.
15. Ooms HWA, Koumans RKJ, Ho Kang Yu PJ, Puylaert JBCM, *Ultrasound in the diagnosis of acute appendicitis. Br J Surg* 1991; 78:315-18. Puylaert JBCM. The appendix. In: David Cosgrove, Hylton Meire, Keith Dewbury [ed]. *Abdominal and General Ultrasound*; Edinburgh, Churchill Livingstone; 1994; Volume 2: 779-84.
16. George MJ, Siba PP, Charan PK, Rao RRM. Evaluation of Ultrasonography as a useful Diagnostic Aid in Appendicitis. *Indian J Surg.* 2002; 64: 436-9.
17. Jeffery RB Jr, Laing FC, Townsend RR. Acute appendicitis: sonographic criteria based on 250 patients. *Radiology* 1988; 167:327-9.
18. Michel Rioux *Sonographic Detection Of The Normal And Abnormal Appendix, AJR* 1992; 158: 773-8.
19. Lee JH, Jeong YK, Park KB, Park JK, Jeong AK, Hwang JC. Operator dependent techniques for graded compression sonography to detect the appendix and diagnose acute appendicitis, *AJR.* 2005 Jan; 184(1):91-7.
20. Thomas Rettenbacher, Alois Hollerweger, Peter Macheiner, Lukas Rettenbacher, Robert Frass, Barbara Schneider, et al presence or absence of gas in the appendix: additional criteria to rule out or confirm acute appendicitis-evaluation with ultrasound, *Radiology* 2000; 214:183-7.
21. Pinto F, Lencioni R, Falleni A, et al.: Assessment of hyperemia in acute appendicitis: comparison between power Doppler and color Doppler sonography. *Emerg Radiol* 1998; 5:92-96.
22. Puylaert JB. A prospective study of Ultrasonography in diagnosis of acute appendicitis. *NEJM.* 1987; 317:666-9.
23. Joshi HM, Patel VB, Dave AN, *Ultrasonographic Evaluation Of Acute Appendicitis, Ind J Radiol Imag.* 1996; 2:75-8.
24. Wade DS, Marrow SE, Balsara ZN, Goff WB, *Accuracy Of Ultrasound In The Diagnosis Of Acute Appendicitis With Surgeon's Impression, Arch Of Surgery* 1993; 128:1039-46.
25. Yacoe ME, Jeffrey B Jr *Sonography of appendicitis and Diverticulitis Radiol Clin N Am* 1994; 32:899-912.
26. Wolf B, Schwerek, Britta Wichtrup, Matthias Rothmund, Joseph Ruschoff, *Ultrasonography In The Diagnosis Of Acute Appendicitis: A Prospective Study, Gastroenterology* Sept 1989: 630-9.
27. Matteo Baldisserotto, Edson Marchionosi, accuracy of noncompressive Sonography of children according to the potential positions of the appendix, *AJR* 2000; 175:1387-92.
28. Ida Chan, Simon G. Bicknell, Mary Graham, *Utility and Diagnostic Accuracy of Sonography in Detecting Appendicitis in a Community Hospital AJR* 2005; 184:1809-12