

ACUTE APPENDICITIS; ULTRASONOGRAPHY AS PRE-OPERATIVE SCREENING TOOL

Amer Hayat Haider, Mohammad Nazir Qureshi*, Rizwan Bila, Ijaz Ahmad

Combined Military Hospital Hyderabad, Pakistan, * Military Hospital Rawalpindi, Pakistan, Combined Military Hospital, Rawalpindi, Pakistan

ABSTRACT

Objective: To determine the accuracy of ultrasonography in confirming acute appendicitis in adult patients presenting with relevant clinical features taking histopathology of removed appendix as the gold standard.

Study Design: Cross-sectional (Validation) study.

Place and Duration of Study: Radiology Department Combined Military Hospital (CMH) Rawalpindi from August 2008 to February 2009.

Material and Methods: A total of 80 cases of clinically suspected acute appendicitis selected on non probability convenience sampling technique were included in the study. They all underwent ultrasound evaluation. Sensitivity, Specificity, Positive Predictive Value (PPV) and Negative Predictive Value (NPV) of Ultrasound and Ultrasound (USG) findings were calculated keeping surgical findings and histopathology of the removed appendix as a gold standard, whenever appendectomy was carried out. SPSS version 16.0 was used to carry out necessary statistical calculations.

Results: Out of 80 patients whose ultrasound examination of right lower quadrant (RLO) was performed, 36 patients were correctly diagnosed as having acute appendicitis on USG out of 42 finally diagnosed cases based on histopathology. Similarly we picked 18 normal appendices out of 38 non-appendicitis patients in which 6 proved to be false negative. This showed that US scan has sensitivity of 86%, specificity 80%, PPV 92%, NPV 67% and overall accuracy of 84%. The most accurate appendiceal finding for appendicitis was a diameter of 6 mm or larger followed by non-compressibility of appendix.

Conclusion: Ultrasound has high diagnostic accuracy in diagnosis of acute appendicitis and helps to reduce negative appendectomy rates. A greater than 6-mm diameter of the appendix under compression is the most accurate US finding.

Keywords: Acute Appendicitis, Appendix, Appendectomy, Ultrasonography, Ultrasound.

This is an Open Access article distributed under the terms of the Creative Commons Attribution License (<http://creativecommons.org/licenses/by/4.0>), which permits unrestricted use, distribution, and reproduction in any medium, provided the original work is properly cited.

INTRODUCTION

Appendicitis is a common etiology of abdominal pain, caused by acute inflammation of the appendix and occurs in approximately 8-10% of the population (over a lifetime)^{1,2}. Acute appendicitis is the most common surgical abdominal emergency worldwide with life time prevalence of one in seven^{3,4}. The diagnosis of acute appendicitis is mainly clinical but because

of myriad presentation clinical assessment is correct only in 80% of the total patients presenting in the ER⁵. To prevent the dire complications of the acute appendicitis, the doubtful cases are preferably operated which resulted in negative appendectomy rate of 10-15% or even more in few cases, considered as acceptable but ultimately carries both the risks of mortality and morbidity⁶. The accurate diagnosis of acute appendicitis is also important due to many other abdominal conditions which may simulate its clinical scenario especially in women of reproductive age group, patients with mass right iliac fossa (RIF) and in the extremes of ages^{7,8}.

Correspondence: Dr Amer Hayat Haider, Combined Military Hospital Hyderabad, Pakistan

Email: amerhayathaider@yahoo.com

Received: 30 Jan 2012; revised received: 28 Dec 2015; accepted: 27 Apr 2016

Routinely, diagnosis of acute appendicitis is made upon the basis of clinical history, physical examination and certain laboratory investigations like total leukocyte count (TLC)⁹⁻¹⁰. In order to improve the diagnostic accuracy different aids have been introduced like different scoring systems, gastrointestinal (GI) contrast studies, ultra sonography (USG), computed tomography (CT) scan, magnetic resonance imaging (MRI), nuclear scan and laparoscopy^{8,11}.

TLC is a commonly performed laboratory investigation due to its availability and cost effectiveness but due to its limited sensitivity and specificity general surgeons require simple, cost effective and readily available supportive investigation to avoid the negative appendicectomies¹².

Many studies have claimed that the NPV of CT scan is around 98%⁹, so certain people especially in the west advocate its importance due to the fact that it is not operator dependent and chances of variations in results in various setup are very less. The limitations of the CT scan abdomen in our setups are its limited availability, high cost and other general disadvantages like extensive radiation dose and chances of contrast reactions that make it a difficult diagnostic tool. So there is utmost need to look for a diagnostic tool that not only carries high sensitivity and specificity but also cost effective, fast and readily available.

USG of the abdomen is yet another practiced investigation; its principle advantage is not its highest accuracy but its non-invasive nature. The diagnostic sign of acute appendicitis is visualization of appendix on USG. However it failed to gain popularity as a pillar of diagnosis in the disease, because it is very much operator dependent and results vary from person to person depending upon the expertise of the sonologist as well as certain patient factors like obesity, gas filled gut loops in front of the appendix, amount of inflammatory fluid around the appendix and position of the appendix may also add in its disadvantages¹³.

The significance of this study is that ultrasound will definitely increase the confidence of general surgeons in diagnosis of acute appendicitis resultantly reducing the negative appendicectomy rate, which will help the patient by reducing the patient's exposure to the mortality, morbidity and certain post operative complications like intestinal obstruction due to adhesions and fertility problems in females^{7,14}. It will definitely reduce the burden on health care system and overall society as undue surgeries have socioeconomic impacts in the form of loss of working days and declined productivity.

The rationale of this study was to add further information and help in better understanding of the role of USG in patients of acute appendicitis. This also highlighted the importance of ultrasound as a useful, readily available, non-invasive and radiation free investigation in these patients. The study was based on the presumption that a thorough appendicitis-specific USG examination yields more accurate diagnosis helping to reduce high negative appendectomy rates and thereby benefiting the affected patients.

MATERIAL AND METHODS

This descriptive (validation) study was conducted at the Radiology Department, Combined Military Hospital Rawalpindi from August 2008 to February 2009.

Patients of both genders more than 18 years of age with presence of relevant clinical features were included in the study.

Patients with mass right iliac fossa, known history of appendicectomy, pregnancy, adnexal mass, right ovarian torsion, or pelvic inflammatory disease (PID) were excluded.

Data Collection Procedure

A total of 80 cases of clinically suspected acute appendicitis selected on non probability convenience sampling technique were included in the study. They all underwent USG evaluation. Sensitivity, Specificity, Positive Predictive Value (PPV) and Negative Predictive Value (NPV) of

Ultrasound and US findings were calculated keeping surgical findings and histopathology of the removed appendix as gold standard whenever appendectomy was carried out. SPSS version 16.0 was used to carry out necessary statistical calculations.

RESULTS

There were 55 (69%) males and 25 (31%) females out of a total sample of 80 patients. The age of the patients ranged from 18 years to 70 years with a mean age of 21 years and SD ± 4. All the patients were subjected to US abdomen within 2-4 hours of presentation in the ER. Findings of USG were matched against the histopathological findings of appendix after surgery.

US diagnosis of acute appendicitis was made in 39 patients who underwent surgery. Histopathology of the resected appendices showed signs of acute appendicitis in 36, whereas

patients, among these 18 US negative patients, persisted to have clinical signs and symptoms of acute appendicitis. Surgical intervention was carried out within 24 hours of US examination and they turned out to be having inflamed appendices on surgery and histopathology (thus giving the non-visualization of the appendix at Ultrasound a NPV of 67%). These were the FN results of US as shown in table-1 and fig-1. Two out of these six patients had perforated appendicitis and the other four had retrocecal appendices.

In 38 non appendicitis patients, diagnosis was confirmed on US in 15 patients, on surgery in 3 patients (3 US false positive cases), on endoscopy in 2 patients and at clinical follow up in 18 patients. Final diagnosis of all the patients is shown in table-2.

Appendix was seen on US in 57 patients out of 80 (71%) including 39 inflamed, 18 normal

Table-1: Breakdown of cases with appendicitis.

		Histopathology Positive		Histopathology Negative	
Ultrasound Positive	39	True Positive	36	False Positive	3
Ultrasound Negative	18	True Negative	12	False Negative	6

Table-2: Final diagnosis of the patients.

	Frequency	Percent	Valid percent	Cumulative Percent
Valid acute appendicitis	42	52.5	52.5	52.5
Pain with no definitive cause	13	16.3	16.3	68.8
Mesenteric lymphadenitis	8	10.0	10.0	78.8
Cystitis	3	3.8	3.8	82.5
GE	6	7.5	7.5	90.0
PID	2	2.5	2.5	92.5
Peptic ulcer	4	5.02	5.02	97.5
Misc	2	2.5	2.5	100

3 appendices turned out to be normal, thus making 3 false positive (FP) US results.

In 41 US negative patients a normal appendix was identified in 18 patients (47% of USG negative patients) and in the remaining 23 (53%) appendix was not identified on US. Six

appendices and appendix was not seen in 23 patients. In these patients, a diameter of 6 mm or larger was the most accurate finding for appendicitis followed by lack of compressibility. Appendicolith was found in only 20% of appendicitis patients.

DISCUSSION

It is agreed upon at various levels that acute appendicitis is the most common surgical emergency worldwide, warranting early surgical intervention to prevent the complications¹⁻³. Even with the advent of modern clinical assessment methods, acute appendicitis always puts the surgeon's clinical judgment into a real test in majority of the cases, especially in the women of reproductive age group and extremes of ages resulting into a challenge for general surgeons not only to prevent complications but also to prevent unnecessary interventions^{7,8}.

The overall accuracy of clinical diagnosis of acute appendicitis is approximately 80% with mean negative appendicectomy rate of 20%, mainly due to the difficulties faced in differentiation of acute appendicitis from other

5 female patients with various gynecological disorders,⁸ with mesenteric adenitis. Probable diagnosis of peptic ulcer was given in one patient and gut perforation in another patient due to peptic ulcer disease, which all turned out the same on follow up. This beautifully demonstrated the benefit of US for the provision of an alternate diagnosis to explain the patient's symptoms providing the opportunity to examine rest of the abdomen and pelvis in a very short acquisition time^{17,18}.

The inability to visualize the normal appendix is classically considered a major weakness of US in the assessment of patients suspected of having appendicitis because it represents a serious limitation to confidently excluding the diagnosis of appendicitis¹⁹.

US evaluation of the appendix ideally

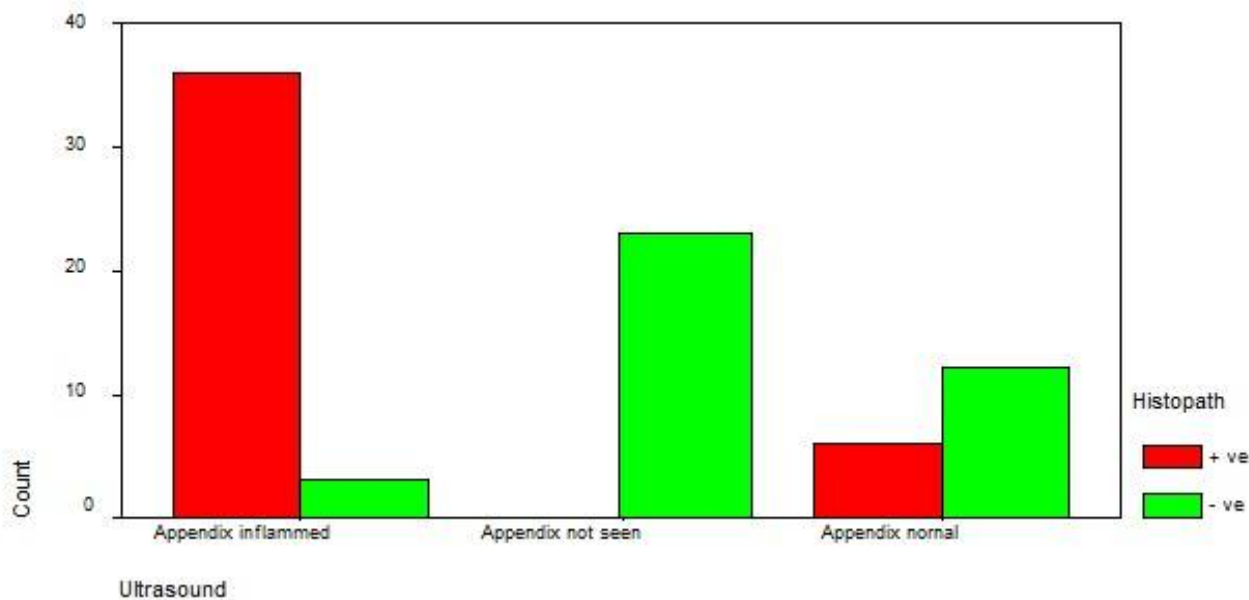


Figure-1: Correlation between US & histopathological findings.

abdominal conditions^{5,6}. To lower the rate of unnecessary surgeries and to improve the diagnostic accuracy, laboratory investigations and imaging have been increasingly used, particularly in equivocal cases^{15,16}.

In patients who were US negative for acute appendicitis (n=38), definite alternative diagnosis were made on US in 15 patients, which included

includes the evaluation of the appendiceal wall and appendiceal content. We decided to measure the outer appendiceal diameter rather than appendiceal wall thickness for two reasons. Inflammation of the appendiceal wall may be difficult to distinguish from hypoechoic intraluminal pus, thus making measurement of the appendiceal wall inaccurate and second the

mucosal surface may be difficult to identify within the appendix²⁰. We found that identification of an appendix measuring less than 6 mm in diameter was an accurate indication to exclude appendicitis, with a NPV of 67%. Which is slightly out of line with the studies by Rettenbacher et al obtained a NPV of 100% with this sign, whereas Rioux reported a NPV of 98% with it^{20,21}. The diameter of 6 mm or above for the diagnosis of an inflamed appendix, which is the most commonly reported threshold, had high PPV (95%) in our study. The high PPV is out of line with the data obtained by Rettenbacher et al who reported an appendiceal diameter of 6 mm or larger in 32% of symptomatic patients without appendicitis in whom the appendix was identified²¹. We found that hyperemia in the appendiceal wall shown on the color doppler images was a specific finding for appendicitis that was encountered in only three of the patients without appendicitis. The same high specificity was already reported in previously published studies in which flow was never identified in the normal appendiceal wall²². This finding, however, showed a sensitivity of only 45%.

Our evaluation of the content of the appendiceal lumen focused on the presence of intraluminal fluid as a sign of appendicitis, whereas Rettenbacher and his fellows considered the absence of gas in the appendiceal lumen as a criterion for appendicitis. The same mechanism might explain both the presence of fluid and the absence of gas in an appendix. Obstruction, which is the most common cause of appendicitis, could lead to retention of pus or appendiceal secretion with resorption of intraluminal gas. We did not evaluate the presence or absence of gas in the appendix because we considered that the US appearance of a tiny appendicolith or a small amount of feces could resemble gas and in addition, its evaluation is easier at CT than at US^{23,24}. By contrast, appendiceal fluid, which is a finding that has never been evaluated to our knowledge, is easier to identify and its presence could be a useful ancillary sign.

To summarize, our study suggests a quick protocol to diagnose acute appendicitis especially in equivocal cases with cost effectiveness, avoiding radiation exposure and intravenous contrast administration.

CONCLUSION

Ultrasound is a noninvasive highly diagnostic investigation with the overall accuracy of 84%. It has improved our ability to detect appendicitis and its complications with improved results and reduced rate of unnecessary surgeries resulting into decreased negative appendectomy rate. In addition various diseases simulating acute appendicitis can also be diagnosed especially in pregnant ladies and extremes of ages. Tissue harmonic ultrasound therefore is an imaging modality of preference in cases of acute appendicitis.

Diameter of inflamed appendix more than 6 mm is the most sensitive US finding for appendicitis with high PPV and NPV followed by non-compressibility of the inflamed appendix. These two US findings together provide the most accurate diagnosis in suspected cases of acute appendicitis.

CONFLICT OF INTEREST

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

REFERENCES

1. Ferri F. Appendicitis. In: Ferri F. Ferri's Clinical Advisor, 12th ed. Philadelphia, Elsevier Mosby; 2012. p. 94.
2. Mohamed A, Bhat N. Acute Appendicitis Dilemma of Diagnosis and Management. The Internet Journal of Surgery. 2009 Volume 23 Number 2.
3. Zahid M, Jamal AU, Akhtar S, Shah TA. Critical review of acute appendicitis in females. Ann King Edward Med Coll 2004; 10:283-6.
4. Khan I, Rehman A: Application of Alvarado scoring system in diagnosis of acute appendicitis. J Ayub Med Coll, Abbottabad 2005, 17: 41-44.
5. SCOAP Collaborative, Cuschieri J, Florence M, Flum DR, Jurkovich GJ, Lin P, Steele SR, Symons RG, Thirlby R. Negative appendectomy and imaging accuracy in the Washington State Surgical Care and Outcomes Assessment Program. Ann Surg. 2008 Oct; 248(4):557-63.
6. Parks NA, Schroepel TJ. Update on imaging for acute appendicitis. Surg Clin North Am. 2011 Feb; 91(1):141-54. [PMID: 21184905]

7. Wolfe J, Henneman P. Acute Appendicitis. In: Marx J, Hockberger R, Walls R, eds. Rosen's Emergency Medicine, 7th ed. Philadelphia, Elsevier Mosby; 2010. p. 1193-9.
8. Howell JM, Eddy OL, Lukens TW, Thiessen ME, Weingart SD, Decker WW; American College of Emergency Physicians. Clinical policy: Critical issues in the evaluation and management of emergency department patients with suspected appendicitis. *Ann Emerg Med.* 2010 Jan;55(1): 71-116.
9. O'Connell PR. The vermiform appendix. In: Russell RCG, Williams NS, Bulstrode CJK, editors. *Bailey & Love's short practice of surgery.* 24th ed. London: Arnold, 2004: 1203-18.
10. Kessler N, Cyteval C, Gallix B, Lesnik A, Blayac PM, Pujol J, et al. Appendicitis: Evaluation of sensitivity, specificity and predictive values of ultrasonography, doppler ultrasonography and laboratory findings. *Radiology.* 2004; 230: 472-8.
11. Yu CW, Juan LI, Wu MH, Shen CJ, Wu JY, Lee CC. Systematic review and meta-analysis of the diagnostic accuracy of procalcitonin, C-reactive protein and white blood cell count for suspected acute appendicitis. *Br J Surg.* 2013. Feb; 100(3): 322-9.
12. Khan MN, Davie E, Irshad K. The role of white cell count and C-reactive protein in the diagnosis of acute appendicitis. *J Ayub Med Coll Abbottabad.* 2004 Jul-Sep;16(3):17-9. PMID: 15631364.
13. Gulzar S, Umar S, Dar GM, Rasheed R. Acute appendicitis- role of clinical examination in making a confident diagnosis. *Pak J Med Sci* 2005; 21(2): 125-32.
14. Khan MN, Davie E, Irshad K. The role of white cell count and C-reactive protein in the diagnosis of acute appendicitis. *J Ayub Med Coll Abbottabad.* 2004 Jul-Sep; 16(3): 17-9.
15. Beasley SW. Can we improve diagnosis of acute appendicitis? *BMJ.* 2000 Oct 14; 321(7266): 907-8. PMID: 11030658
16. Malik KA, Khan A, Waheed I. Evaluation of Alvarado score in the diagnosis of acute appendicitis. *J Coll Physicians Surg Pak.* 2000; 10: 392-4.
17. Puig S, Hörmann M, Rebhandl W, Felder-Puig R, Prokop M, Paya K. US as a primary diagnostic tool in relation to negative appendectomy: six years experience. *Radiology.* 2003 Jan; 226(1): 101-4. PubMed PMID: 12511675
18. Mardan MAK, Mufti TS, Khattak I, Chilkunda N, Alshayeb AA, Mohammad AM, Rehman Z. Role of ultrasound in acute appendicitis. *J Ayub Med Coll Abbottabad Sep* 2007; 19(3): 72-9
19. Yabunaka K, Katsuda T, Sanada S, Fukutomi T. Sonographic appearance of the normal appendix in adults. *J Ultrasound Med* 2007;26(1):37-43
20. Sharma R, Kasliwal DK, Sharma RG. Evaluation of negative appendectomy rate in cases of suspected acute appendicitis and to study the usefulness of ultrasonography in improving the diagnostic accuracy. *Indian J Surg.* 2007 Oct; 69(5): 194-7.
21. Yaqoob J, Idris M, Alam MS, Kashif N. Can outer-to-outer diameter be used alone in diagnosing appendicitis on 128-slice MDCT? *World J Radiol.* 2014 Dec 28; 6(12): 913-8
22. Paulson EK, Kalady MF, Pappas TN. Clinical practice. Suspected appendicitis. *N Engl J Med.* 2003 Jan 16; 348(3):236-42.
23. Gabrielle AE, Hasina RN, Ravelonarivo R, Ahmad A. Intestinal parasites simulating appendicitis on ultrasound: about two cases. *Pan Afr Med J.* 2015 Aug 31; 21: 322.
24. Singh S, Jha AK, Sharma N, Mishra TS. A case of right upper abdominal pain misdiagnosed on computerized tomography. *Malays J Med Sci.* 2014 Jul; 21(4): 66-8.