

Accuracy of Ultrasound in the Diagnosis of Acute Appendicitis and Correlation with Histopathology

Shrestha A¹, Khadka H¹, Poudel B², Basnet R³, Basnet SB¹

¹Department of Radiology and Imaging, National academy of medical sciences, Kathmandu, Nepal

²Department of Surgery, National academy of medical sciences, Kathmandu, Nepal

³Department of Pathology, National academy of medical sciences, Kathmandu, Nepal

Received: November 10, 2018

Accepted: November 25, 2018

Published: December 30, 2018

Cite this paper:

Shrestha A, Khadka H, Poudel B, Basnet R, Basnet SB. Accuracy of ultrasound in the diagnosis of acute appendicitis and correlation with histopathology. *Nepalese Journal of Radiology* 2018;8(12):13-19. <https://doi.org/10.3126/njr.v8i2.22975>

ABSTRACT

Introduction: Acute appendicitis is a common surgical condition; yet its diagnosis can be elusive at times and missed diagnosis can lead to attendant complications of perforation and its sequelae. On the contrary, negative appendectomy subjects one to unnecessary surgery and its physiological and psychological consequences. Among the various available modalities of diagnosis of appendicitis, Ultrasonography(USG) is easily accessible, non invasive, less time consuming, low cost investigation no radiation hazards. So, USG is appropriate diagnostic modality in our country.

Methods: This prospective observational study was carried out from January 2011 to June 2011, in the radiology department of Bir hospital. Total of 80 cases with clinical impression of acute appendicitis were enrolled. These patients underwent surgery for suspected acute appendicitis. Details of signs and symptoms, lab findings including Total Leukocyte count (TLC), Differential Leukocyte Count (DLC) and USG findings were recorded. Intra-operative and histopathology findings were also recorded. The findings were analyzed to assess accuracy of ultrasonography in acute appendicitis. Histopathological report was considered the goal standard.

Results: A total of 93 cases clinically diagnosed as acute appendicitis were subjected for USG. Out of 93 cases, 80 cases underwent surgery. Among 80 cases, sonography showed acute appendicitis in 56 cases out of which 54 was proved by histopathology as well. However, ultrasonography was not able to detect appendicitis in 9 cases. The sensitivity and specificity of USG for acute appendicitis were 87.7% and 88.2% respectively. The positive and negative predictive values were 96.4% and 62.5% respectively. Overall negative appendectomy rate of 21.2% had been used a basis for decision making, the rate of error being 13.7%.

Conclusion: Ultrasonography is a fairly accurate and safe modality in acute appendicitis. It can be useful in reducing negative appendectomy rate.

Key Words: Appendicitis; Appendectomy; Ultrasonography

Correspondence to: Dr. Aimandu Shrestha

Department of Radiology and Imaging
National academy of Medical Sciences
Kathmandu, Nepal

Email: shresthaaimandu@gmail.com

INTRODUCTION

Acute appendicitis refers to acute inflammation



Licensed under CC BY 4.0 International License which permits use, distribution and reproduction in any medium, provided the original work is properly cited

of the vermiform appendix, which is a blind ended tube arising from the caecum. It is vestigial organ but it can become diseased. Appendicitis is a surgical emergency, and if it is left untreated the appendix may perforate and cause potentially fatal complications especially in children and elderly. The overall mortality rate for acute appendicitis is less than 1% but is higher in elderly, more than 5% to 15%.¹

Despite technological advances, diagnosis of acute appendicitis is still based primarily on history and clinical examination. Prompt diagnosis and surgical referral may reduce the risk of perforation and prevent complications.² Patients with acute appendicitis typically present with central abdominal pain shifting to the right lower quadrant (RLQ) or may present with generalized abdominal pain. Vomiting is common in children. Clinical examination reveals signs of acute intra-abdominal process e.g., local and rebound tenderness, muscle guarding, rigidity, cutaneous hyperaesthesia and tenderness on rectal examination. Since about one third of patients with acute appendicitis present with atypical symptoms.³ Differential diagnosis is diverse and includes gastroenteritis, mesenteric lymphadenitis, ovarian and tubal disorder, renal colic, peptic ulcer and acute cholecystitis.

Ultrasonographic criteria of acute appendicitis include blind-ended, non-compressible, aperistaltic tube, with diameter more than 6 mm, arising from the tip of caecum with a gut signature. Visualization of an appendix with an appendicolith, regardless of appendiceal diameter is also regarded as a positive test. However, normal appendix can also be visible on ultrasound. Normal appendix is compressible with wall thickness of less than or equal to 3 mm. The size of appendix can differentiate normal from acutely inflamed appendix. The threshold level for the diameter of the appendix above which acute appendicitis is very likely is 6 mm.⁴

Routine investigations like total leucocyte count, differential count and plain X-ray abdomen, have been recommended to improve the diagnosis. Plain abdominal radiographs have an overall accuracy of only 8%.⁵ The routine laboratory examination of blood and urine is mandatory. Leucocytosis is useful but non-specific. It may be absent particularly in very young and old patients.³

There has been numerous publications on the use of ultrasound as a diagnostic tool. These studies demonstrate sensitivity of 75%-94% and specificity 87%-96%. Several prospective studies have been conducted where the result of ultrasonography were used as an aid for surgeons in making an operative decision. Helical CT has reported sensitivity of 90%-100%, specificity of 91%-99%, accuracy of 94%-98%, positive predictive value of 92%-98%, and negative predictive value of 95%-100% for the diagnosis of acute appendicitis.^{6, 7, 8}

This study was conducted to evaluate diagnostic accuracy of ultrasound in acute appendicitis. The study was based on the presumption that an accurate diagnosis helps to reduce high negative appendectomy rates and thereby benefit the patients.

METHODS

This prospective observational hospital based study was done at Bir hospital, NAMS after obtaining approval from the Institutional Review Board (IRB) from January 2011 to June 2011. Patients more than 15 years of age diagnosed clinically as acute appendicitis were included in the study. Patients in whom ultrasonography could not be performed and those not undergoing surgery were excluded from the study. Patients were subjected for abdominal ultrasonography. USG diagnosis of acute appendicitis was based on the criteria of Jeffery et al⁹ which includes:

Non compressible, immobile, blind ended tubular structure with target appearance in transverse view, diameter of visualized structure more than or equal to 6 mm. Supportive features are inflamed perienteric fat, pericaecal collection, appendicolith.⁹ Sonographic findings that met all criteria were diagnosed as positive for appendicitis. All attempts were made to rule out or establish other causes of right lower quadrant pain sonographically.

All the findings including history, clinical examination, laboratory investigation and ultrasound findings were recorded. Intraoperative findings were recorded and histopathologic reports of specimen were noted. The histopathological diagnosis of acute appendicitis would be based on the finding of neutrophilic infiltration of the muscularis propria. The operative diagnosis of acute appendicitis would be based on finding of swollen, shiny /dull, granular redness of appendix judged by attending surgeon.

Results of ultrasonographic impression were compared to clinical impression, intraoperative findings and histopathological reports. Sensitivity, specificity, positive predictive value, negative predictive value and accuracy were computed and comparisons made. Fisher's exact test was utilized to compare USG and intraoperative findings while Chi square test was used to compare USG findings with histopathology.

RESULTS

A total of 93 cases were clinically diagnosed as acute appendicitis and subjected for USG. Out of 93 cases only 80 cases underwent surgery, 13 cases being excluded from the study. Out of excluded 13 cases, 7 cases were found to have an early appendicular lump on sonography, 2 cases had appendicular abscess, 2 cases had right ureteric calculus and 1 was normal. One case was diagnosed as acute appendicitis sonographically but patient refused surgery.

In these 80 cases, sonography showed acute appendicitis in 56 cases, of which 54 were confirmed by histopathology. One was normal appendix and another Meckel's diverticulum by histopathology. Intra-operatively 53 were acute appendicitis, 2 were normal appendix and 1 was Meckel's diverticulum. Twenty four cases were normal by sonography, of which 9 were histopathologically diagnosed as acute appendicitis.

Age range of study group was from 16 to 70 years. The mean age was 27.64 years. Standard deviation was 9.6 years. Sixty three cases were histologically acute appendicitis. There were 40 (63.5%) males and 23 (36.5%) females. Male female ratio was 1.6:1. Sex distribution consisted of 40 (63.5%) male and 23 (36.5%) female. Common age group consisted of 16-25 yrs (47.6%) and 26-35yrs (34.9%). There were no cases in age group 56-65yrs and above 75yrs during the course of this study.

Among 63 cases with histological diagnosis of acute appendicitis, 51 (80.95%) cases had raised leukocyte counts ($>11,000/\text{mm}^3$) and 12 (19.05%) cases had normal leukocyte counts ($4000-11000/\text{mm}^3$). Out of 63 cases, 41 (65.08%) cases showed target sign and 22 (34.92%) cases had no target sign. Fifty six patients had an appendix diameter more than 6mm, two patients had $<6\text{mm}$ and in 22 cases appendix could not be visualized. Among those with non- visualization, 9 actually had appendicitis on histopathology. Fifty four cases with appendiceal diameter $> 6\text{mm}$ diameter. had acute appendicitis histopathologically

Out of 80 cases which underwent surgery during the course of study, sonographic diagnosis of acute appendicitis was made in 56 cases and 24 cases were ruled out as acute appendicitis. Among sonographically diagnosed 56 cases, 53 cases were also diagnosed as acute appendicitis intraoperatively, while 1 case

diagnosed as Meckel's diverticulum and 2 cases had normal appendix. Among the 24 cases which were sonographically ruled out as acute appendicitis, 15 cases were diagnosed as acute appendicitis and 9 cases as normal appendix intraoperatively. We found ultrasonography has sensitivity of 77.9%, specificity of 75%, positive predictive value of 94.6%, and negative predictive value of 62.5% and accuracy of 77.5 % in acute appendicitis as compared to intraoperative findings.

Out of 80 cases which underwent surgery during the course of study, sonographic diagnosis of acute appendicitis was made in 56 cases and 24 cases were ruled out as acute appendicitis. Among sonographically diagnosed 56 cases, fifty four cases were histopathologically diagnosed as acute appendicitis while 1 case diagnosed as Meckel's diverticulum and 1 case as normal appendix. Among the 24 cases which were sonographically ruled out as acute appendicitis, 9 cases were diagnosed as acute appendicitis and 15 cases as normal appendix histopathologically. In our study, ultrasonography has sensitivity of 85.7%, specificity of 88.2%, positive predictive value of 96.4%, negative predictive value of 62.5% and accuracy of 86.25% as compared to histopathology findings in acute appendicitis. Out of 80 cases which underwent surgery during the course of study, intraoperative diagnosis of acute appendicitis was made in 68 cases and 12 cases were ruled out as acute appendicitis. Among intraoperatively diagnosed 68 cases, 62 cases were histopathologically diagnosed as acute appendicitis, 1 case diagnosed as Meckel's diverticulum and 5 cases as normal appendix. Among the 12 cases which were surgically ruled out as acute appendicitis 1 case was diagnosed as acute appendicitis and 11 cases as normal appendix histopathologically. We found intraoperative diagnosis has sensitivity of 98.4%, specificity of 64.4%, positive predictive value of 89.7%, negative predictive

value of 91.6% and negative appendectomy of 21.2% as compared to histopathological findings in acute appendicitis.

DISCUSSION

In our study out of 80 total cases, 63 cases were acute appendicitis histopathologically, out of them 40 (63.5%) were male and 23 (36.5%) were female, male female ratio was 1.6:1 and mean age was 27.64 years. The most common age group was 16-25 years followed by 26 -35 years. In a study by Sigdel et al¹⁰ done in Kathmandu, mean age was 27.5 years and male to female ratio was 2.6. In most other studies too there is male preponderance.¹¹ Our study was supported by Berry et al⁵. In his study of 246 cases, there was male predominance with 60.2% male and 39.5% females. In a study by Khattak et al¹² out of 663 cases, 447 were male and 216 were female with male female ratio of 2:1. Peak incidence was 2nd and 3rd decade which is also comparable to our study.

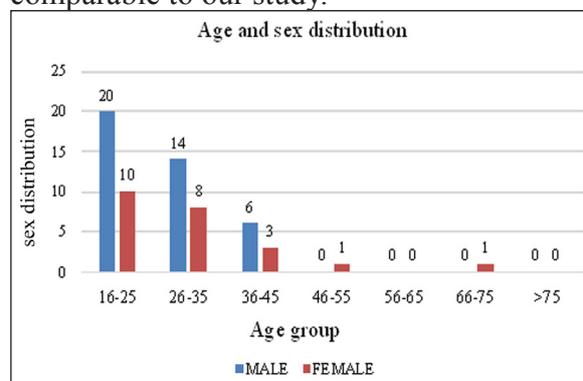


Figure 1: Age and sex distribution

In another study by Omran et al¹³, 58% of patients were male and age specific incidence of acute appendicitis followed similar pattern for male and female which is also comparable to our study. In our study, increased Leukocyte was found in 80% cases of histopathologically diagnosed acute appendicitis. However increased leukocytosis is not reliable indicator. Our study was supported by several other studies.^{14, 15, 16} In the present study, USG showed a transverse

diameter of appendix of ≥ 6 mm in 54 cases, <6 mm in 2 cases and appendix was not visible in 22 cases. The visibility of normal appendix on sonography is controversial. Puylaert⁶ in his study concluded that normal appendix is not seen in USG. In contrary to this, studies done by Jeffery et al¹⁷ and Rioux¹⁸ documented the visibility of normal appendix.

Table 1: Correlation of ultrasound with operative findings

		Intra-op		Total
		Yes	No	
USG abdomen	Yes	53	3	56
	No	15	9	24
Total		68	12	80

Transverse diameter ≥ 6 mm was highly significant in diagnosing acute appendicitis. Our study showed a strong correlation between appendicular transverse diameter of ≥ 6 mm on USG and histopathology ($P < 0.001$). The sensitivity and specificity using transverse diameter as a criteria for diagnosing acute appendicitis in present study was 85.7% and 88.2% respectively. Study done by Kesler et al¹⁹ also concluded that threshold diameter of 6 mm is the most accurate USG finding for appendicitis.

In our study, USG diagnosis, when compared to histopathology, had an accuracy of 86.25%. Ultrasonography correctly identified 54 cases with appendicitis while it also identified 15 cases who had no appendicitis. However there were 9 false negative cases and 2 false positive cases. Had USG been used as a basis for decision making, 9 cases that actually had appendicitis would have been missed. However of these 9 cases, in 7 patients initial clinical diagnosis was also non-confirmatory; they had been conservatively managed initially and decision to operate was taken after 24 hours in view of changed clinical picture.

Table 2: Correlation of ultrasound with histopathology

		HPE		Total
		Yes	No	
USG abdomen	Yes	54	2	56
	No	9	15	24
		63	17	80

In our study, negative appendectomy rate was 21.2%, i.e. an accuracy of 78.8%. Compared to our USG diagnosis had a higher accuracy at 86.25%. Thus it appears USG may help in reducing negative appendectomy rates. The accuracy in our study was higher than Mohammad et al²⁰. Rioux¹⁸ and Karstrup et al²¹ had similar accuracy; 86% and 86.9% respectively. Meanwhile Abu et al²² had higher accuracy than our study.

In our study USG had sensitivity of 85.7% and specificity of 88.2%. Thus USG was found to be more specific than sensitive. Karstrup et al²¹, Rioux¹⁸ and Masek et al²⁴ have reported higher sensitivities while Fung et al²³, Horton et al²⁵ and Mohammed et al²⁰ had lower sensitivity levels. Similarly, our specificity rate was comparable to that by Fung et al²³. It was lower than that reported by Abu-Yousef et al²², Rioux¹⁸ and Masek et al²⁴. Karstrup et al²¹ and Mohammad et al²⁰ had lower specificity levels. The PPV of USG in our study was 96.4% and NPV was 62.5%. Abu et al²³ had lower PPV but higher NPV than ours. Rioux et al¹⁸ and Fung et al²³ obtained similar results. Mohammad et al²⁰ had both lower PPV and NPV values compared to our study.

There are certain limitations to our study. Firstly the sample size is small and we have not included pediatric population. Secondly, ultrasonography findings vary when the same patient is examined at different points in time or by different clinician, i.e. inter observer variation may be present. So the findings, and consequently the diagnostic accuracy may improve when a review scan is done, especially

in those cases that present very early.

CONCLUSION

The sensitivity and specificity of USG in our study was comparable to most other studies; it was more specific than sensitive; thus USG can be more useful to help to confirm the diagnosis of appendicitis rather than ruling it out, i.e. a normal USG cannot rule out appendicitis.

CONFLICT OF INTEREST

None

SOURCES OF FUNDING

None

REFERENCES

1. Fitz RH. Perforating inflammation of the vermiform appendix: with special reference to its early diagnosis and treatment. *Am J Med Sci* 1886;92:321-346. Available from: <http://resource.nlm.nih.gov/65711100R> [Accessed 20th Dec 2018].
2. Wilcox R.T, Traverso LW. Have the evaluation and treatment of the acute appendicitis changed with new technology? *Surg Clin North Am* 1997;77(6):1355-1370 [https://doi.org/10.1016/S0039-6109\(05\)70622-8](https://doi.org/10.1016/S0039-6109(05)70622-8)
3. Lewis FR, Holcroft JW, Boey J, Dunphy JE. Appendicitis: A critical review of diagnosis and treatment in 1000 cases. *Arch surg* 1975; 110(5):677-684. <https://doi.org/10.1001/archsurg.1975.01360110223039>
4. Wilson SR. The Gastrointestinal Tract. In: Rumack CM, Wilson SR, Charboneau JW, Levine D, editors. Diagnostic Ultrasound. 3rd ed. China: Elsevier Mosby; 2005.p.295.
5. Berry J, Malt RA. Appendicitis near its centenary. *Ann Surg* 1984;200(5):567-575. <https://doi.org/10.1097/00000658-198411000-00002>
6. Puylaert JB. Acute appendicitis: US evaluation using graded compression. *Radiology* 1986;158(2):355-360. <https://doi.org/10.1148/radiology.158.2.2934762>
7. Larson JM, Pierce JC, Ellinger DM et al. The validity and utility of sonography in the diagnosis of acute appendicitis in the community setting. *Am J Radiol* 153;(4):687-91.
8. Buchman TG, Zuidema GD. Reasons for delay of the diagnosis of acute appendicitis. *Surg Gynecol Obstet* 1984;158(3):260-266. Available from: <https://www.ncbi.nlm.nih.gov/pubmed/6701739> [Accessed 20th Dec 2018]
9. Jeffery RB, Liang FC, Townsend RR. Acute appendicitis: Sonographic criteria based on 250 cases. *Radiology* 1988;167(2):327-329. <https://doi.org/10.1148/radiology.167.2.3282253>
10. Sigdel GS, Lakhey PJ, Mishra PR. Tzanakis score vs. Alvarado score in acute appendicitis. *J Nepal Med Assoc* 2010;49(178):96-99. <https://doi.org/10.31729/jnma.105>
11. Addiss DG, Shaffer N, Fowler BS. The epidemiology of appendicitis and appendectomy in the United States. *Am J Epidemiol* 1990;132(5):910-925. <https://doi.org/10.1093/oxfordjournals.aje.a115734>
12. Khattak S, Aslam S, Kamal A. Acute appendicitis: an audit of 663 cases. *Gomal Journal of Medical Sciences* 2010;8(2):209-211. Available from: <http://citeseerx.ist.psu.edu/viewdoc/download?doi=10.1.1.102.0.9797&rep=rep1&type=pdf> [Accessed 20th Dec 2018].
13. Omran MA, Mamdani MM, Mcleod RS. Epidemiologic features of acute appendicitis in Ontario, Canada. *Can J Surg* 2003;46(4):263-265. Available from: <https://www.ncbi.nlm.nih.gov/pubmed/12711100>

- nih.gov/pmc/articles/PMC3211626/# [Accessed 20th Dec 2018].
14. Coleman C, Thompson JE, Bennion RS, Schmit PJ. White blood cell count is a poor predictor of severity of disease in the diagnosis of appendicitis. *Am Surg* 1998;64(10):983-985. Available from: <https://search.proquest.com/openview/fad2e8dc75a555f26d58f37386a43169/1?pq-origsite=gscholar&cbl=49079> [Accessed 20th Dec 2018].
 15. Tehrani HY, Petros JG, Kumar RR, Chu Q. Markers of severe appendicitis. *Am Surg* 1999;65(5):453-455. Available from: <https://search.proquest.com/openview/38c1b4c03a98ef1a1427159b188756e6/1?pq-origsite=gscholar&cbl=49079> [Accessed 20th Dec 2018].
 16. Thompson MM, Underwood MJ, Dookeran KA, Llyod DM, Bell PRF. Role of sequential leucocyte counts and C-reactive protein measurements in acute appendicitis. *Br JSurg* 1992;79(8):822-824. <https://doi.org/10.1002/bjs.1800790839>
 17. Jeffrey RB, Laing FC, Lewis FR. Acute appendicitis: High resolution real time US findings. *Radiology* 1987;163(1):11-14. <https://doi.org/10.1148/radiology.163.1.3547490>
 18. Rioux M. Sonographic detection of the normal and abnormal appendix. *Am J Radiol* 1992;158(4):773-778. <https://doi.org/10.2214/ajr.158.4.1546592>
 19. Kessler N, Cyteval C, Gallix Bet al. Appendicitis : evaluation of sensitivity , specificity , and predictive values of US , Doppler US , and laboratory findings. *Radiology* 2004;230(2):472-478. <https://doi.org/10.1148/radiol.2302021520>
 20. Mohammad MAA, Mufti TS, Khattak IU, Chilkunda N, Alshayeb AA, Mohammad AM. Role of ultrasound in acute appendicitis. *J Ayub Med Coll Abbottabad* 2007;19(3):72-79. Available from: <http://ayubmed.edu.pk/JAMC/PAST/19-3/17%20Akbar.pdf> [Accessed 20th Dec 2018].
 21. Karstrup S, Pederson TS, Roikjaer O. Ultrasonic visualization of the inflamed appendix. *Br J Radiol* 1986;59(706):985-986. <https://doi.org/10.1259/0007-1285-59-706-985>
 22. Abu-Yousef MM, Bleicher JJ, Maher JW, Urdaneta LF, Franken EA, Metcalf AM. High resolution sonography of acute appendicitis. *Am J Roentgenol* 1987;149(1):53-58. <https://doi.org/10.2214/ajr.149.1.53>
 23. Fung HS, Lau S, Siu JCW, Chan CM, Chan SCH. Audit of ultrasonography for diagnosis of acute appendicitis: a retrospective study. *J HK Coll Radiol* 2008;11:108-111. Available from: <http://docshare01.docshare.tips/files/9742/97429165.pdf> [Accessed 20th Dec 2018].
 24. Masek T, Poulouva M, Schwarz J, Bavor P. Ultrasonography as an auxiliary method in diagnosis of acute appendicitis. *Rozhl Chir* 2003;82(6):320-323. Available from: <https://www.ncbi.nlm.nih.gov/pubmed/12898783> [Accessed 20th Dec 2018].
 25. Horton MD, Counter SF, Florence MG, Hart MJ. A prospective trial of computed tomography and ultrasonography for diagnosing appendicitis in the atypical patient. *The American journal of surgery* 2000;179(5):379-381. [https://doi.org/10.1016/S0002-9610\(00\)00372-X](https://doi.org/10.1016/S0002-9610(00)00372-X)