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

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Abstract Acute appendicitis is commonest cause of acute abdomen necessitating emergency abdominal surgery. Although diagnosis is still largely considered to be a clinical one, ultrasound is established as easily available, less time consuming and very accurate at timely diagnosis of acute appendicitis largely reducing complications as well as negative laparotomies. Due to development of high frequency transducers and better resolution, ultrasound is highly specific and sensitive in diagnosis of acute appendicitis. This study was done to establish the diagnostic role of ultrasound in acute appendicitis in western region of Nepal. Total number of 125 patients were included in the study from May 2013 to May 2015. Findings on ultrasound were finally compared with histopathological report of appendices removed on surgery. Those cases with alternate diagnosis were followed up and proved with other means of investigation. The sensitivity, specificity, positive predictive value, negative predictive value and overall accuracy of ultrasound in diagnosis of acute appendicitis in our study were found to be 95.12 %, 88.88 %, 97.5% , 80% and 82 % respectively.

Keywords: *appendicitis, ultrasonography, specificity, Nepal*

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1. Introduction

Acute appendicitis is the commonest cause of emergency abdominal surgery [1]. It is one of the leading causes of the acute abdomen [2]. Without a classic presentation of pain around umbilicus migrating towards right lower quadrant, diagnosis may be difficult. Gynecologic pathologies may also cause diagnostic dilemma. To cut down on morbidity, early and accurate diagnosis of appendicitis is essential before appendicitis progresses to perforation.

Even though the diagnosis of acute appendicitis is still thought to be a clinical one, a significant number of patients have normal appendices at surgery. Wrong diagnosis of appendicitis has led to a high rate (8-30%) of inappropriate removal of the normal appendix [3]. Although acute appendicitis has typical clinical presentation in 70% of the cases, about 30% of the patients have an uncertain pre-operative diagnosis due to which there is negative laparotomy in as high as 20-25% cases. The rate of such unnecessary laparotomies is even higher (35-45%) in women of childbearing age, because of the female pelvic organs and complications of pregnancy in this group [4]. In the past 2 decades, the negative appendectomy rate has been relatively constant with slight decline after 2000, but the rate of perforated appendicitis seems to be increasing [5]. This high rate can be decreased by careful and accurate diagnosis of appendicitis thus preventing acute appendicitis to progress to perforation and peritonitis [3].

The rate of perforation is increasing, with an average high of 23%, which is partially because of delayed surgery caused by uncertain diagnosis. Plain film diagnosis depending on the occasional demonstration of appendicolith or ureteric calculus is neither sensitive nor specific. The diagnosis of acute appendicitis by the barium enema studies is mainly based on the demonstration of non-filling of the appendix. It is not frequently used and it has an accuracy that ranges from 50-85%. White cell and anti-granulocyte scintigraphic scans have also been used in the diagnosis of right lower quadrant pain, but are expensive, time consuming and are not very sensitive. Computed tomography is considered to be sensitive and specific for the diagnosis of acute appendicitis, but the thin sections that often necessitates a more focused examination increases the possibility of missing pathology outside the field of view. It is a relatively expensive test that often requires introduction of oral and intravenous contrast agents. Besides CT is neither sensitive nor specific for the diagnosis of gynecologic disease, a frequent mimicker of acute appendicitis.

Ultrasound has also been shown to be highly sensitive and specific for the diagnosis of not only acute appendicitis but also other conditions that cause right lower quadrant pain [6]. It was not possible to routinely evaluate acute appendicitis routinely till the development of high resolution real time sonography. But at present

with availability of high frequency transducers, it is easier to diagnose appendicular pathologies owing to its better resolution. Graded compression sonography is particularly useful in cases of suspected uncomplicated acute appendicitis. Obvious benefits of ultrasound are

i No ionizing radiation, non-invasive
ii Minimal discomfort to the patient
iii Easy availability, portability, and repeatability
iv No specific patient preparation required.

In many centers, sonography has become the procedure of choice for the initial evaluation of acute appendicitis with equivocal clinical features, particularly in pediatric and women of childbearing age group.

Very few studies have been conducted in our part of the country and sufficient data was not available regarding the role of sonography in the evaluation of clinically suspected cases of appendicitis. Hence, this study was conducted to establish the role of sonography either in diagnosis or in ruling out appendicitis as the cause of acute abdomen, thus enabling in avoiding unnecessary negative laparotomies.

2. Aims & objectives

The specific aim of our study was to determine the following with USG in suspected acute appendicitis:

- specificity
- sensitivity
- positive predictive value
- negative predictive value
- accuracy.

3. Methodology

A structured pre-prepared case proforma was used to enter the complete history, investigations-hematological and ultrasound, per-operative findings and histopathological report.

3.1. Criteria for evaluation and definitions

Visualization of inflamed appendix or identification of periappendiceal abscess with ultrasound was considered positive for the diagnosis of appendicitis. Visualization of appendix less than 6mm or non-visualization was recorded as a negative result.

If the inflamed appendix could be identified, the largest outer diameter was measured using electronic calipers. A histopathological examination of surgically removed appendices, formed the basis for definitive judgement.

Diagnosis in patients not undergoing surgery were verified by evaluating all examinations, including follow up observations.

3.2. Selection Inclusion Criteria

All Patients irrespective of age and sex clinically suspected to be having acute appendicitis.

3.3. Exclusion Criteria

1. Moribund patients not fit for surgery
2. Complications of appendicitis like abscess, lump etc.
3. Cases of acute appendicitis not willing for further management were excluded from the study.
4. Patients not giving consent
5. Pregnant patients

3.4. Sonological Equipment Used

ACUSON X300 and LOGIQ P3 with multi-frequency linear array transducer (7.5MHz-10.0MHz) and curvilinear transducer (3.5MHz-7.0MHz) was used for our study.

3.5. Method of Examination

All US studies were performed with the 7.5-10.0MHZ linear array transducer. In women a US 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.

The method of examination in this study was as per the graded compression technique described by Puylaert [7].

3.6. Ethical Clearance

Prior to the study, ethical approval from the institutional ethical committee was taken. Informed consent was taken from all the patients involved in the study and confidentiality was maintained.

3.7. Sample size Calculation

In a pilot study done prior to this study, showed sensitivity of USG in diagnosis of acute appendicitis as 95%, with 95% CI and 5% allowable error. Sample size required was 80 [8].

4. Results

Out of 125 patients included in our study, 105 patients underwent surgery and ultrasound findings were correlated with histopathology report as shown in Table 1.

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

Total No of Cases	Proven On Histopathology	Sonography			
		True Positive	True Negative	False Positive	False Negative
125	105	98	20	2	5

Appendix was visualized in total 100 cases with associated other features of inflammation as described in Table 2.

Table 2. USG Findings in Histopathologically Proven Appendicitis

USG Findings	No. of Cases	Percentage
Visualization of Appendix	100	95.23
Target Sign on Transverse Scan	100	95.23
Sonographic Mcburney's Tenderness (Probe Tenderness)	105	100
Appendicolith	8	7.6
Free Fluid in Right Iliac Fossa	70	66.66
Echogenic Surrounding Mesentery	85	80.95
Loss of Submucosal Integrity	30	28.57

Out of 100 cases reported as appendicitis on ultrasound, 98 were found to be appendicitis on histopathology where as 2 of them were negative for appendicitis as shown in Table 3.

Table 3. Correlation of Ultrasound with Histopathological Examination Report

Total Number of Cases	125
USG positive	100
USG negative	25
HPE positive	98
HPE negative	2
USG negative cases operated	15
HPE positive	5
HPE negative	10
Results	
True positive	98
True negative	20
False positive	2
False negative	5

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 4.

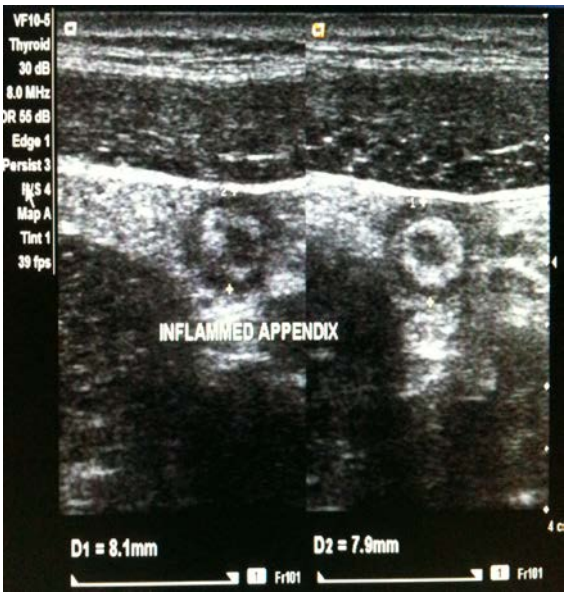

Figure 1. USG showing target sign of inflamed appendix with wall to wall diameter of 8.1mm

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

Table 4. Diagnostic Role of USG

Evaluation of USG	Values (%)
Sensitivity	95.14
Specificity	90.90
Positive Predictive Value	98
Negative Predictive Value	80
Diagnostic Accuracy	94.4

5. Discussions

Our study was a prospective study of 125 patients clinically suspected for acute appendicitis. After a detailed history and clinical examination, the patients were subjected to ultrasound examination of the right iliac fossa using graded compression technique as explained by Puylaert using high resolution, high frequency probes (linear array 7.5-10MHz and curvilinear array 3.5-7.0MHz).

Age prevalence showed less than 4.8 % of patients in the age group of 1-10 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 1.62:1. These results were comparable to the study done by Lewis et al [9] who observed that less than 10% of patients were affected in the age group of 1-10 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 11-20 years followed by age group of 21-30 years which is consistent with the findings shown by Addis et al [2] that it is most common in 10 to 19 year old age group.

5.1. Symptoms

Patients presented with various symptoms among which 73.8 % 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 [9] 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 study done by Tauro LF et al [10] in which 37 % patients of acute appendicitis had fever No significant difference in the presentation of illness was seen in other causes of right lower quadrant pain in our study compared to acute appendicitis. This is in conformity with the study done by Lewis et al [9].

5.2. Signs

In the current study, tenderness in right iliac fossa was seen in 100 % cases whereas rebound tenderness at McBurney's point was noted in 92.85% of patients which is similar to the finding noted by Tauro LF et al [10] which showed 100% patients having right iliac fossa tenderness and 65 % patients having rebound tenderness at McBurney's point. Sohail et al. [11] emphasized the same finding that scanning the point that the patient says hurts the most increases the detection rate of appendicitis.

5.3. 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.

5.4. Ultrasonography in the Diagnosis of Acute Appendicitis

Puylaert [7] was the pioneer of graded compression sonography in the diagnosis of acute appendicitis.

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 USG could visualize 98 appendices out of 125 cases who had clinical presentation of acute appendicitis, from which true positive cases of appendicitis were found after 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 3 normal appendices accounting for 2.4 % of the total number of cases. This finding is similar to study done by Jeffrey et al [17]. 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 the remaining 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 McBurney's point. In 95 cases (90.47 %) of the total number of cases where we could see an inflamed appendix, it was non-compressible and spherical in shape in all the cases. It is in accordance with Grebeldinger [21] who has concluded that the most relevant criteria for USG evaluation was non-compressibility (97.67%). The outer diameter of the appendix was greater than 6mm in all the 95 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 %. In this study, sensitivity, specificity, positive predictive value and negative predictive value of ultrasound scanning with reference to histopathological confirmation was 95.12 %, 88.88 %, 97.5% and 80% respectively which showed that USG has a high specificity and sensitivity in diagnosing appendicitis. The overall specificity and sensitivity rates were comparable to the studies and results of Skanne et al [22], Hahn et al [23] , Tarzan Z et al [24] and Puylaert et al [25] whose specificity values varied from 90- 100% and sensitivity ranges varied from 70-95%.

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.

Table 5. Comparative Results in Different Studies

References	Sensitivity (%)	Specificity (%)	Positive predictive Value (%)	Negative predictive value (%)	Accuracy (%)
Present study	95.12	88.88	97.5	80	94
Joshi et. al [26]	96	93	98	88	95
Rioux et al [18]	93	94	86	98	94
Puylaert et al [25]	89	100	-	-	-
Wolf et al [31]	96	93	98	88	95.7
Rettenbacher et al [20]	100	68	63	100	79
Kessler N et al [12]	98	98	98	98	97
Baldisserotto et al [32]	98.5	98.2	98	97	-
Chan et al [33]	83	95	86	94	92
Lee et al [19]	99	99	-	-	99
Tauro LF et al [10]	91.37	88.09	91.37	88.09	90

Our results are comparable to Joshi et al. [26] who reported diagnostic accuracy of 95 %, sensitivity of 96 %, specificity 93 % , positive predictive value of 93 % and negative predictive value of 88 %.

This study results are also similar to study done by Tauro LF et al [10] who showed sensitivity of 91.37 %, specificity of 88.09 %, positive predictive value of 91.37%, negative predictive value of 88.09 % and diagnostic accuracy of 90 %.

Out of the 125 cases of this study, 115 cases underwent appendicectomy of which 103 cases were proved to be acute appendicitis by histopathological examinations. Among the 125 cases, ultrasonography was positive in 100 cases. Among the operated USG positive cases of appendicitis, 98 cases were acute appendicitis on histopathological examination. Thus, 98 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 15 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 15 cases, five were positive for acute appendicitis on histopathological examination. These 5 cases were taken as false negative cases. The remaining ten cases were considered true negative. Other eight cases in which we gave alternating diagnosis like right renal calculus, right ureteric calculus and bowel mass which later proved to be caecal malignancy were also taken as true negative cases. Hence, total number of true negative cases in our study was 20.

5.5. Factors Influencing 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 [26] 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 [27] who mentioned that the results would not be so impressive if the operator did not have enough experience. However, Cheshbrough et al [28] included Radiology residents in his study and observed that the accuracy of ultrasonography did not diminish and reported an accuracy of 86% in his study.

5.6. Factors Influencing False Negative Diagnosis of Acute Appendicitis

It is reported by Yacoe and Jeffrey [29] 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.

5.7. Role of Ultrasound in Giving an Alternative Diagnosis

Ultrasound not only diagnosed acute appendicitis but also identified other conditions mimicking appendicitis. In our study, 10 (8 %) cases had alternate diagnosis, where graded compression sonography was negative. In these cases the patients were managed conservatively based on our report. Nine cases of renal calculi and ureteric calculi were also proved by X- ray KUB and later by Intravenous Pyelography study. One case was followed up which was diagnosed as carcinoma caecum after proper evaluation. Thus we could prevent negative laparotomy in these cases. This is consistent with the studies of Gaensler et al [14] and Emmie M Fa et al [30]. Hence we were able to either prevent a negative laparotomy or influence the surgical management.

6. Conclusion

Acute appendicitis is commonest acute abdominal condition, requiring emergency surgery. If clinical signs and the 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.

Surgery followed by histopathological examination was final proof of acute appendicitis.

USG can be used as a valuable tool in diagnosing acute appendicitis in spite of sophisticated investigations like CT abdomen and laparoscopy; thus, reducing the cost of treatment and preventing negative laparotomies.

Limitations of the Study

The study did not include diagnostic laparoscopy, which is recent modality of diagnosis and treatment of acute appendicitis. We did not include contrast CT abdomen for the accurate diagnosis of doubtful cases due to the cost factor.

Declaration of Conflicting Interests

The authors declare that there is no potential conflicts of interest with respect to the research, authorship and /or publication of this article.

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