

Original Article

Diagnostic Accuracy of Graded Compression Ultrasonography in Diagnosis of Acute Appendicitis Taking Histopathology as Gold Standard

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Abstract: Acute appendicitis is a common surgical abdominal emergency in this part of the world with a life time prevalence of one in seven. As this disease is amenable for treatment by surgery, early diagnosis plays an important role in treatment and in preventing undue complications. The objective of this study was to determine diagnostic accuracy of graded compression ultrasonography in the diagnosis of acute appendicitis taking histopathological as gold standard. This was a prospective study was carried out in the Department of Radiology at Nepal Mendicity Hospital Brhaspati, Lalitpur, Nepal. All the patients with a clinical diagnosis of Acute Appendicitis underwent Graded Compression Ultrasonography and their findings were documented on a proforma. All the patients who underwent Appendectomy were followed on and histopathology diagnosis was considered as Final Diagnosis. Sonographic and histopathological diagnosis were correlated. Out of a total of 102 cases studied, 97 (95%) were diagnosed to have Acute Appendicitis, rest had alternate diagnosis. The sensitivity, specificity, positive predictive value and negative predictive value of graded compression ultrasonography in the diagnosis of acute appendicitis was 90.72 %, 40 %, 96.7 % and 18.18 % respectively. The false negative value was 0.09 and false positive value was 0.6. Graded Compression Ultrasonography is highly accurate to diagnose appendicitis. The accuracy afforded by sonography will help keep negative appendectomy rates down, clearly an improvement over the rate achieved by clinical diagnosis alone.

Keywords: appendicitis, appendix, ultrasonography, sensitivity, specificity

1. INTRODUCTION

Acute appendicitis is a common surgical abdominal emergency in this part of the world with a life time prevalence of one in seven [1]. As this disease is amenable for treatment by surgery, early diagnosis plays an important role in treatment and in preventing undue complications [2]. As the complications for misdiagnosis are dire, the common surgical practice has been to operate on clinical diagnosis alone rather than to wait and watch till the diagnosis is certain. This resulted in negative appendectomy of 20-30% and has been considered acceptable [3]. This concept has been challenged with present day use of technique and technology. Unlike older generation, today's patients are definitely aware and panic about removing a normal appendix and moreover removal of a normal appendix is not a benign

procedure and negative appendectomy also carries a significant rate of morbidity [4]. In about 30% of patients the signs, symptoms and laboratory findings of acute appendicitis are atypical often leading to delay in diagnosis and surgical intervention and consequent increase in rate of perforation and morbidity [5]. In order to ascertain the diagnosis, different aids were introduced like computer aided programs, different scoring systems, gastro intestinal tract contrast studies, CT scan, Ultrasonography (USG), MRI and Laparoscopy. Among all these modalities, USG is safer, more economic, more convenient, non-invasive and readily available diagnostic modality [6]. Ultrasound can diagnose a number of conditions that mimic appendicitis clinically. If appendicitis can be excluded sonologically and an alternative diagnosis be made, two benefits will occur. Unnecessary appendectomy can be avoided and appropriate treatment instituted. Ultrasound can be recommended in children where there is diagnostic doubt [7]. In young men, limited number of alternative diagnoses usually permits a high degree of diagnostic accuracy. In contrast, young women commonly present with acute gynecological illnesses that closely mimic acute appendicitis. Reported negative appendectomy rates in ovulating women thus remain disturbingly high and range from 34%- 46% [8]. Lack of early diagnosis results in appendicular perforation and complications such as intra-abdominal abscess, wound infection, infertility and death [9]. In 1986 Graded Compression Ultrasonography for diagnosing acute appendicitis using high frequency linear array transducers in supine position. It is considered as the sole indicator for diagnosis of acute appendicitis in the original description. However, the gold standard for the diagnosis of appendicitis still remains postoperative histopathology confirmation [10]. After Puylaert advocacy, many studies on the usefulness of graded compression sonography have reported varying detection rates for the vermiform appendix with varying sensitivities of 76-96% and specificities of 91-100% for the diagnosis of acute appendicitis [11]. Rioux et al described detection rate for the normal appendix was 82%, but there are some other studies with lower rates. Posterior manual compression technique during graded compression sonography shows added usefulness for detecting the vermiform appendix and for diagnosing acute appendicitis. However there are some difficult conditions where USG cannot diagnose or exclude the acute appendicitis due to some because of limiting factors such as the operator-dependent technique, the retrocecal location of the appendix, and patient obesity [12]. According to an author the accuracy rate of graded compression ultrasonography in diagnosing acute appendicitis in comparison to histopathology results was 86.5% with sensitivity, specificity, positive predictive value and negative predictive value of 86.5%, 86.6%, 99.8% and 32.5% respectively [13]. These results regarding the accuracy and sensitivity agree with the study done by Hiwa, where they are as 83.3% and 82.1% respectively. However that study reported a high specificity that reached 100%. A study reported the accuracy of to be 96.6%, sensitivity 96%, and specificity 93%. The study results agree with that of Pinto et. al, which demonstrated an overall sensitivity of ultrasonography as 86%, specificity 81%, and accuracy of 84% [14]. This study was used to determine diagnostic accuracy of graded compression ultrasonography in the diagnosis of acute appendicitis taking histopathological as gold standard.

2. MATERIALS & METHODS

This study was conducted at department of Radiology, Nepal Mendicity Hospital, Brhaspati Lalitpur, Nepal. This was a prospective cross-sectional study conducted in the department of Radiology, Nepal Mendicity Hospital. All the cases referred for Ultrasonography with a clinical diagnosis of acute appendicitis and who underwent appendectomy were included. Ultrasonography was performed immediately after a clinical diagnosis of Acute Appendicitis. Ultrasonography was repeated in a few cases. These patients were treated surgically or conservatively depending on the condition of the patient. They were followed up over a period till they were discharged. Histopathological diagnosis was taken as a gold standard and correlated with sonographic findings. The sample size was calculated by taking sensitivity and specificity of sonography as 85.6%(24) and specificity as 86.6%(24) with

prevalence of acute appendicitis as 44.27%(32) with margin of error of 10%. The calculated sample size was 102 patients. Non-probability consecutive sampling technique was utilized in this study. All patients who met inclusion criteria, attending Radiology department of Nepal Mendicity Hospital were assessed for eligibility and were enrolled in this study after approval of study protocol by ethical review committee. Patients were explained about research protocol and informed written consent were taken. Demographic details of the patient along with the clinical details from the emergency and or outpatient clinic file were recorded accordingly. The procedure was performed by minimum 3 years experienced radiologist. Radiological evaluation by high-resolution real-time ultrasonography was performed by Samsung ultrasound machine with a LA 3-16 MHz probe in longitudinal and transverse planes using Graded Compression Technique. Usually, no preparation was necessary. The patients were asked to point out the area of maximum tenderness, which was scanned first. If the appendix was not be visualized, scanning of the right lower quadrant was performed in a routine fashion in the transverse plane starting from a point below the tip of the caecum and moving cephalad to the middle of the transverse colon. Examination in the longitudinal plane was used to confirm all findings. Scanning was done in the supine position of the patient while applying graded compression. The findings were correlated and confirmed by post appendectomy histopathology reports and labeled as acute appendicitis. Data were collected on study specific proforma filled by myself. Closed ended proforma was used in this study. Proforma was adopted from similar type of study. The filled proforma were thoroughly checked and edited for the completeness and accuracy on the same day of data collection. Data entry was recorded using the Epi Data (version 3.2). The entered data were transferred into a statistical analysis program (SPSS, version 21.0) for analysis. Data from quantitative variables such as age and BMI was expressed as mean $\pm$ Standard Deviation. Frequency and percentage were calculated for qualitative variables like positive graded compression ultrasonological diagnosis of acute appendicitis and positive or negative post appendectomy histopathology report for acute appendicitis. Effect modifiers/confounders like age, gender and BMI were addressed by applying sensitivity, specificity, accuracy and positive predictive value by making 2x2 table.

3. RESULTS & DISCUSSION

There were 102 patients included in this study. Male and female ratio was 1.55:1. The patients age ranged from 18 years to 50 years with mean (SD) age of 33.14 $\pm$ 10.10 years and median of 35 years. Sixty-one percentages of the participants were male. Majority of the patients was in the 4th decade of their life. The mean weight and height of the patients were 63.95 $\pm$ 9.45 Kg and 162.29 $\pm$ 7.82 cm respectively. The mean BMI of the patients was 24.3 $\pm$ 3.5 kg/m². The mean MANTRELS score was 8.

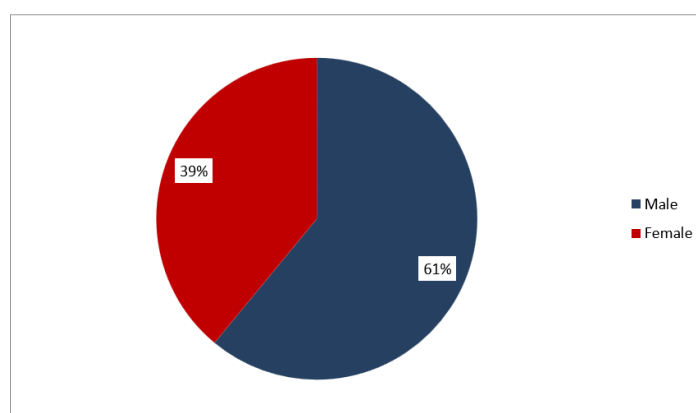


Figure 01: Gender distribution of the patients

Table 01: Age distribution of the patients

Age (Years)	Number of Patients	Percentage
≤ 20	20	19.6%
21-30	18	17.7 %
31-40	25	24.5 %
41-50	39	38.2%
Total	102	100 %

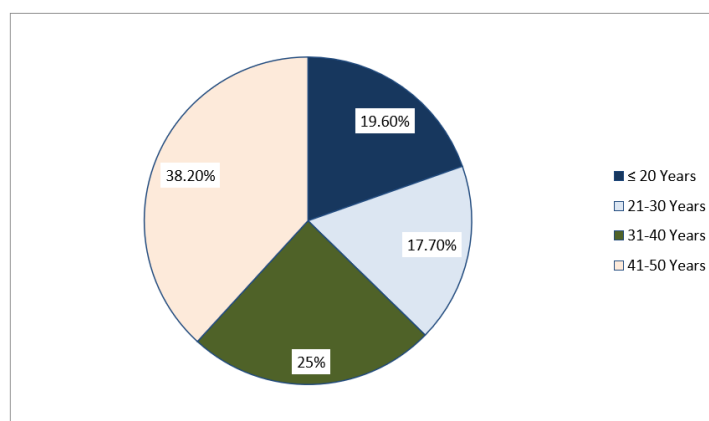


Figure 02: Showing age distribution of the patients

Graded abdominal ultrasonography was done in all the patients. It showed positive finding suggestive of acute appendicitis in 91 patients. All patients showed positive probe tenderness. Distended appendix giving target sign was seen in 91 patients (89.2%) and free fluid in the RIF was observed in 22 patients (21.6%).

Table 02: Showing sonographic findings

USG Findings	Number (%)
Probe tenderness	102(100)
Distended Appendix giving Target sign	91(89.2)
Free fluid	22(21.6)

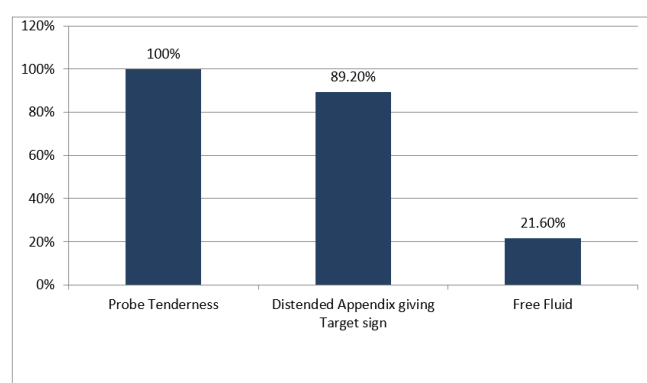


Figure 03: Showing sonographic findings

All of them underwent appendectomy. Intra operatively, the position of the appendix was also assessed. 78 % of the patients had retrocecal and retro colic appendix followed by 12 % with pelvic position.

Table 03: Position of Appendix

Position of Appendix	Number of Patients	Percentage (%)
Retro Cecal and Retro Colic	80	78
Pelvic	11	11
Sub Cecal	6	6
Pre-Ileal and Post Ileal	4	4
Sub Hepatic	1	1

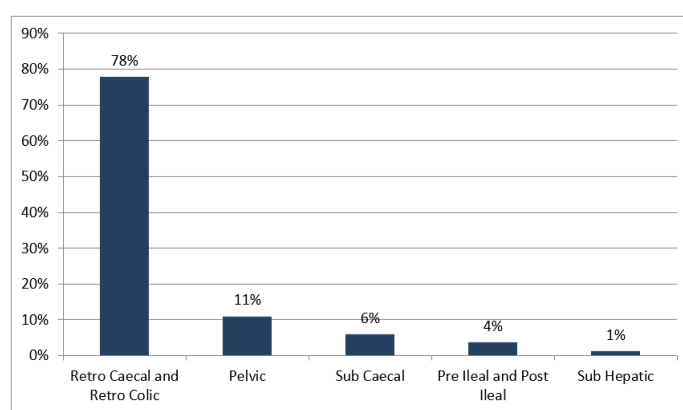


Figure 04: Representing positions of appendix

Following the appendectomy, histopathological status of the resected appendix was assessed. Ninety-seven patients (95%) had acute appendicitis, whereas 1 patient showed foci of endometriosis and another one showed low grade mucinous neoplasm. No histopathological features of acute appendicitis or other disease were seen in 3 patients (3%). Two of patient had negative features of acute appendicitis on graded ultrasonography as well as in histopathology, but had undergone appendectomy on clinical ground. Among those who had shown negative findings suggestive of acute appendicitis on compression graded ultrasonography study, however underwent appendectomy on clinical background, nine patients were found to have acute appendicitis on histopathology. It was considered as false negative result of the graded ultrasonography in the diagnosis of acute appendicitis in this study.

Table 04: Histological status of resected appendix

Disease	No: of patients	Percentage of patients
Acute Appendicitis	97	95 %
Foci of endometriosis	01	1 %
Mucinous Neoplasm	01	1%
Normal Appendix	03	3 %
Total	102	

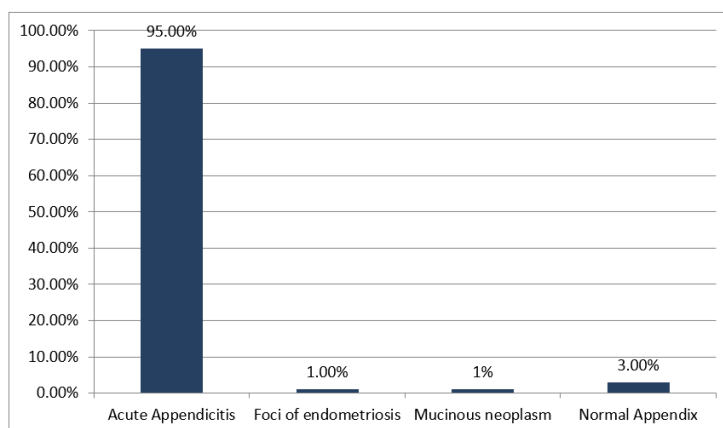


Figure 05: Showing histopathological status of resected appendix

Table 05: Calculation of Sensitivity and Specificity

Sonographic Diagnosis	Patients with Disease	Patients without Disease
Positive	88	3
Negative	9	2

Table 06: Sensitivity, specificity, positive predictive value and negative predictive value of Graded Compression Ultrasonography extracted from this study in the diagnosis of acute appendicitis were

	Sensitivity	Specificity	PPV	NPV	False positive rate	False Negative rate
USG	90.72%	49%	96%	18.8	0.6	0.09

DISCUSSION

The diagnosis of Appendicitis is not always straight forward and sometimes even the most experienced surgeon can end up removing a normal appendix or worse can even wait on perforated ones [15]. For patients with RLQ abdominal pain, the questions to be answered are if the pain is due to appendicitis or any other disease which may mimic the same. There is an increase in the clinical value in diagnosis of acute appendicitis due to evolution of graded compression technique [16]. Basically, Ultrasonography is a dynamic real time imaging technique without any hazards of ionization as with that of X-rays. It is a cost-effective investigation and less time consuming. It can be used safely in pregnancy as well. The clinical presentation of acute appendicitis is typical in more than 70% of patients. About 30 % of patients have an uncertain preoperative diagnosis. Consequently, the rate of unnecessary laparotomy for acute appendicitis is as high as 20-25 %. The rate is even higher (35-45 %) in women of child bearing age group because of pelvic inflammatory disease and complicated pregnancies [17]. So, ultrasonographic examination of RLQ abdominal pain is necessary for these patients. This forms the basis of our study. In our study among 102 cases 62 patients were male and 40 patients were female. The male: female ratio was 1.55:1. According to a study period of 2000-2005, the male to female ratio was 2.2:1 [18]. Our study also showed more males suffer from appendicitis as compared to females. In our study highest number of patients with acute appendicitis was in the age group of 41-50years and constitutes 38.20 % of cases. The next affected age group was 31-40 years and constitutes 25 % of total cases. Mean age of the patient was 33 years.

According to a study period of 2000-2005, the mean age was 27. According to a study mean age was 26 years. According to another study mean age was 21.8 years [19]. The mean age of presentation in our study showed greater age than that of other studies. In our study we have observed Retro Cecal appendix in 64 cases (78 %) of total cases, pelvic in 9 cases (11%), Sub Cecal in 5 cases (6%), Pre-Ileal and Post Ileal in 3 cases (4%) and Sub hepatic in 1 case (1 %). According to another study the appendix was Retro Cecal and Retro colic in 65.28 %, pelvic in 31.01 %, Sub Cecal in 2.26 %, Pre-Ileal in 1 % and Post Ileal in 0.4 % [20]. In Ghana authors reported that the most common position of appendix is retrocecal and pelvic. In our study we have taken the maximum outer diameter of the normal appendix as less than or equal to 6 mm as a sonographic criterion. Mean diameter of appendix in our study was 9.80 mm. An author have taken 6 mm as the maximum outer diameter of normal appendix as a cutoff point and sonographic criterion for enlarged appendix [21]. An author in his study have taken maximum outer diameter greater than 6 mm as a sonographic criterion for acute appendicitis. Mean diameter of their study was 8.7 mm [22]. We have used the same criteria for the diagnosis of acute appendicitis in this study. In our study, Sensitivity and Specificity of Graded Compression Ultrasonography in diagnosis of acute appendicitis was 90.72 % and 40 % respectively. Sensitivity of ultrasonography in a study was 89.9 % with specificity of 96.2%. In a study sensitivity and specificity were 92.7% and 94.5% respectively. In a study sensitivity was 98.9 % and specificity was 90% [23]. In a study in 1986 study the specificity was 100 % specificity.[24] False negative rate in our study was 0.09. These patients were grossly obese with thick abdominal wall, so we couldn't locate the appendix and were proved to be retrocecal appendix at surgery. In a study false negativity rate of 4 % was reported. In our study false positive rate was 0.6. In a study a false positivity rate was 2 % [25]. In our study, positive predictive value (PPV) of Graded Compression Ultrasonography in the diagnosis of acute appendicitis was 96.7% and negative predictive value (NPV) was 18%. In a study in 1987 the positive predictive value was 93 % and negative predictive value was 94.3%, In a study in 2010 study PPV was 94.4 % and NPV was 92.5%. In a study PPV was 98.9 % and NPV was 90% [26] Specificity and negative predictive value of graded compression USG was less in our study as compared to prior studies. The difference might be due to the fact that negative appendectomy was very less in our study, resulting in low number of true negative. Most cases where there was doubtful diagnosis of acute appendicitis underwent CT to rule out the diagnosis and did not undergo surgery. Only few cases underwent appendectomy without CT despite negative USG report due to high index of clinical suspicion. CT has also shown to have high predictive values in acute appendicitis and can be used in obese patients and doubtful cases. Sensitivity of CT is better than ultrasound because of multiple reasons like fat in omentum and is not operator dependent but specificity parallels.

4. CONCLUSIONS

The following conclusions were made after studying 102 cases of suspected acute appendicitis using Graded Compression Ultrasound using high frequency linear array transducer. About 38.2 % of cases occur in between 4th decade. Males are more affected than females, Male: Female ratio was 1.55: 1. Commonest Ultrasound feature in our study was target sign. Commonest position of appendix in our study was retrocecal appendix. Mean appendicular diameter in our study was 9.80 mm. Mean appendicular muscle wall thickness in our study was 3.4 mm. False negatives in our study were 9, false positives were 3 Sensitivity of our study was 90.72 %. Specificity of our study was 49 %. Predictive value of positive test was 96 %. Predictive value of negative test was 18.8 %

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