Medicine

Role of Ultrasonography in the Diagnosis of Acute Appendicitis

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Abstract		Original Research Article

Introduction: Acute appendicitis is still prevalent as a major surgical emergency. Due to the fast progress of the ailment, surgery is often the most sensible approach to manage it. But any surgery comes with its fair share of risk. If the diagnosis of the disease can be made more accurate prior to surgery, the error rate of negative appendectomy can be greatly reduced. ***Aim of the study:*** The aim of the study was to evaluate the role of ultrasonography in the diagnosing acute appendicitis. ***Methods:*** This prospective cross-sectional study was conducted at the Institute of Nuclear Medicine & Allied Sciences (INMAS), Rangpur with Department of Surgery & Department of Pathology of Rangpur Medical College Hospital, Rangpur, Bangladesh. The study duration was 02 years, from 01January 2022 to 31 December 2023. A total of 100 cases were selected from those patients were come for ultrasound examination, send from the hospital with pain in the right lower quadrant of the abdomen for the purpose of this study. ***Result:*** Among the 100 participants of the study, histopathological diagnosis showed that 86% were acute appendicitis cases and 14% had normal appendicitis. Gender or age had no significant association with histopathological diagnosis, but male prevalence was observed in the study, with a high prevalence of young adults. The original site of pain was periumbilical pain shifted to the right iliac fossa for half the participants. Pain duration was between 18-24 hours for 36% of the cases. All participants presented with pain, fever, anorexia, and nausea had a high prevalence among participants. The sensitivity and specificity of high-resolution ultra-sonogram were 84.9% and 85.7% respectively. ***Conclusion:*** Appendicitis is a disease of the young, and can occur in participants of both genders. Histopathological diagnosis has no significant association with patient age or gender. Ultra-sonogram has high sensitivity and specificity ratio in diagnosing acute appendicitis and also has a high positive predictive value but low negative predictive value.
Keywords: Appendix, Appendicitis, Histopathological, Unremarkable, Ultra-sonogram.

INTRODUCTION

Acute appendicitis remains one of the most frequent surgical emergencies [1]. The diagnosis of this condition is largely based on clinical evaluation [2]. A typical patient presents with right lower abdominal pain, nausea, and vomiting, along with tenderness and guarding in the right iliac fossa during examination. However, these signs and symptoms can resemble many other acute abdominal conditions [3]. The situation is further complicated by the varying position of the appendix [4]. Despite numerous advancements in diagnostic methods, the diagnosis remains uncertain in 30-40% of cases [5]. The definitive diagnosis of acute appendicitis still relies on clinical judgment, supported by relevant tests. High diagnostic accuracy is crucial to minimize the rate of unnecessary appendectomies, which remains as high as 20% [6]. Recent research indicates that the incidence of appendicitis is approximately 50%

among women of reproductive age [7]. Many studies suggest appendicitis to be a disease in young adults [8]. It was once referred to as a disease of developed countries, linked to high protein consumption, but its incidence is also rising in developing nations. Beyond a thorough history and physical examination, total and differential leukocyte counts, ESR, and CRP levels can prevent half of unnecessary surgeries and reduce the rate of negative appendectomies (to 15.2%) as well as the risk of appendix rupture [9, 10]. If WBC, ESR, and CRP levels are normal before surgery, it is unlikely that acute appendicitis is present, and the surgeon should consider alternative diagnostic methods [11]. Leukocyte count is the most valuable test, and in cases of non-perforated appendicitis, the leukocyte count shows a slight increase [12]. An Elevated leukocyte count can help confirm acute appendicitis among patients [13]. The measurement of CRP in most studies has also been

effective in the approval of Acute appendicitis [14]. Appendectomy has a complication rate of 4-15%, along with the associated costs and discomfort of hospitalization and surgery. Therefore, the surgeon's primary objective is to achieve an accurate diagnosis as early as possible. Puylaert popularized the use of ultrasonography for diagnosing acute appendicitis in 1986, exactly one hundred years after Fitz published the first study on the condition [15, 16]. Moreover, it has been shown that ultrasound is highly sensitive and specific for diagnosing various conditions that cause right lower quadrant pain, including acute appendicitis [17]. Before the advent of high-resolution real-time sonography, evaluating acute appendicitis was not consistently feasible. However, with the current availability of high-frequency transducers and enhanced resolution, identifying appendicular disorders has become easier. In our region, there have been very few studies, and there is a lack of sufficient information regarding the use of sonography for assessing clinically suspected cases of appendicitis. To avoid unnecessary negative laparotomies, this study aimed to evaluate the role of sonography in diagnosing or excluding appendicitis as the cause of acute abdomen.

OBJECTIVE
General Objective
- To evaluate the role of ultrasonography in the diagnosing acute appendicitis

METHODS
This prospective cross-sectional study was carried out in Institute of Nuclear Medicine & Allied Sciences, Rangpur with Department of Surgery & Department of Pathology of Rangpur Medical College Hospital, Rangpur, Bangladesh. The study spanned two years, from 01January 2022 to 31 December 2023. A total of 100 cases were selected from patients come to Ultrasound Examination send from hospital with pain in the right lower quadrant of the abdomen. Informed written consent was obtained from either the patient or their legal guardian before participation in the study. The study received ethical approval from the hospital's ethical review committee. Data for all participants were collected at the time of examination using a questionnaire specifically designed for the study. Routine investigations reports, including hemoglobin levels, total leukocyte count, differential leukocyte count, ESR, and urine R/M/E, were collected for all cases. Additionally, X-rays of KUB, CRP levels, and high-resolution ultrasound of the entire abdomen were also performed. All cases underwent emergency

appendectomy following a standardized surgical protocol & histopathological reports were collected. After data collection, the information was processed and analyzed using SPSS version 16.0. Statistical analysis was performed, with a p-value of 0.05 or less considered statistically significant.

Inclusion Criteria
- Patients aged ≥15 years (Both genders)
- Patients presenting with pain in the right lower quadrant of the abdomen.
- Patients who had given consent to participate in the study.

Exclusion Criteria
- Patients aged <15 years
- Patients with a presentation of urological, gynecological, or surgical problems other than appendicitis
- Patients with mass in the right iliac fossa.
- Unable to answer the criteria question.
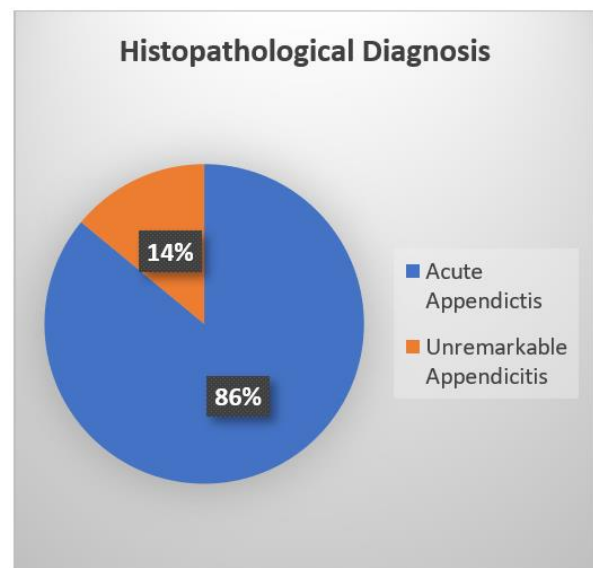- Patient who had no other relevant investigations.

RESULTS

Figure 1: Histopathological diagnosis of the study participants (n=100)

The figure shows the distribution of the patients on the basis of histopathological diagnosis. According to the diagnosis, acute appendicitis was observed in 86% of the patients, while the remaining 14% had unremarkable or normal appendicitis.

Table 1: Association between the age group of the patients and histopathological diagnosis (n=100)

Age	Histopathological diagnosis		P-Value[*]
	Acute appendicitis n (%)	Unremarkable Appendix n (%)	
15-20	40(46.51)	3(21.43)	
21-30	28(32.56)	5(35.71)	
32-40	10(11.63)	3(21.43)	
41-50	5(5.81)	2(14.29)	0.093
51-60	3(3.49)	1(7.14)	
Mean Age	28.571±1.202		
Total	86(100.00)	14(100)	

*Fisher's Exact test was employed to analyze the data

The study analyzed the association between patient age groups and histopathological diagnosis. Among the 100 patients, 86 (86%) were diagnosed with acute appendicitis, while 14 (14%) had an unremarkable appendix. The age group 15-20 years had the highest incidence of acute appendicitis, accounting for 46.51% of cases, with 21.43% of patients in this group having an unremarkable appendix. In the 21-30 age group, 32.56% of patients had acute appendicitis, while 35.71% had an unremarkable appendix. For patients aged 31-40 years,

11.63% were diagnosed with acute appendicitis, and 21.43% had an unremarkable appendix. The incidence of acute appendicitis decreased in older age groups, with 5.81% and 3.49% of patients aged 41-50 and 51-60 years, respectively, diagnosed with acute appendicitis. The P-value for this association was 0.093, indicating no statistically significant relationship between age and histopathological diagnosis. The mean age of patients diagnosed with acute appendicitis was 28.57 ± 1.20 years.

Table 2: Association between gender of the patients and histopathological diagnosis (n=100)

Gender	Histopathological Diagnosis		P* Value
	Acute appendicitis n (%)	Unremarkable Appendix n (%)	
Male	51(59.3)	7(50.0)	0.163 (NS)
Female	35(40.7)	7(50.0)	
Total	86(100.0)	14(100.0)	

Among the 100 patients, males represented 59.3% of acute appendicitis cases, while 50% of patients with an unremarkable appendix were male. Females accounted for 40.7% of acute appendicitis cases, and

similarly, 50% of the patients with an unremarkable appendix were female. The P-value for this association was 0.163.

Table 3: Distribution of patients according to site of pain (n=100)

The original site of pain	Frequency	Percentage
Peri-umbilical pain shifts of RIF	50	50.0
Right iliac fossa	30	30.0
Epigastric pain shifted to RIF	13	13.0
Whole abdomen	7	07.0
Total	100	100.0

The distribution of patients based on the site of pain revealed that 50% of patients initially experienced peri-umbilical pain that later shifted to the right iliac fossa (RIF). A total of 30% reported pain directly in the

right iliac fossa, while 13% experienced epigastric pain that shifted to the RIF. Additionally, 7% of patients reported experiencing pain across the whole abdomen.

Table 4: Distribution of patients according to the duration of pain (n=100)

Duration of the pain	Frequency	Percentage
<6 hours	5	5.0
6-12 hours	9	9.0
12-18 hours	11	11.0
18-24 hours	36	36.0
24-48 hours	27	27.0
>48 hours	12	12.0
Total	100	100

Regarding the duration of pain, the majority of patients (36%) had pain lasting between 18-24 hours, followed by 27% who experienced pain for 24-48 hours. A smaller percentage of patients reported pain lasting for less than 6 hours (5%) or for 6-12 hours (9%), while 11% experienced pain for 12-18 hours, and 12% reported pain lasting more than 48 hours.

Table 5: Distribution of patients according to clinical presentation (n=100)

Clinical presentation	Frequency	Percentage
Pain	10	100.0
Fever	66	66.0
Anorexia	85	85.0
Nausea	65	65.0
Vomiting	53	53.0
Diarrhea	13	13.0
Constipation	25	25.0

In terms of clinical presentation, all patients (100%) reported experiencing pain, with anorexia being the next most common symptom, affecting 85% of patients. Fever was present in 66% of cases, while 65% experienced nausea. Vomiting was reported by 53% of patients, and less common symptoms included constipation (25%), diarrhea (13%), and diarrhea (13%).

Table 6: Distribution of patients according to clinical findings (n=100)

Primary Variables	Secondary Variables	Frequency	Percentage
Pulse	≤100/min	76	76.0
	>100min	24	24.0
Temperature	<98.6°F	15	15.0
	98.6-100°F	61	61.0
	>100°F	24	24.0
Tenderness	Localized	71	71.0
	Diffuse	29	29.0
Muscel guard	Present	64	64.0
	Absent	36	36.0
Pointing sign	Present	82	82.0
	Absent	18	18.0
Rebound tenderness	Positive	76	76.0
	Negative	24	24.0
Rovsing's sign	Positive	70	70.
	Negative	30	30.0
Psoas test	Positive	60	60.0
	Negative	40	40.0
Obturator	Positive	43	43.0
	Negative	57	57.0

The study evaluated various clinical findings and characteristics among the patients. In terms of pulse rate, 76% of patients had a pulse rate of ≤100/min, while 24% had a pulse rate exceeding 100/min. Regarding temperature, 61% of patients had a temperature between 98.6°F and 100°F, 24% had a temperature greater than 100°F, and 15% had a temperature below 98.6°F. Tenderness was localized in 71% of patients, with the remaining 29% having diffuse tenderness. Muscle guarding was present in 64% of patients, and 82% displayed a positive pointing sign. Rebound tenderness was positive in 76% of cases, and Rovsing's sign was positive in 70% of patients. Additionally, the psoas test was positive in 60% of cases, while the obturator test was positive in 43% of patients.

Table 7: Distribution of the patient based on the position of the appendix (n=100)

Position of appendix	Frequency	Percentage
Retrocaecal	68	68
Pelvic	28	28
Paracaecal	1	1
Subcecal	2	2
Postileal	1	1
Total	100	100

The distribution of patients based on the position of the appendix revealed that the most common position was retrocaecal (68%), followed by pelvic (28%). Other less common positions included paracaecal (1%), subcecal (2%), and postileal (1%).

Table 8: Concordance of Ultra-sonogram and histopathological diagnosis (n=100)

High-resolution Ultra sonogram diagnosis	Histopathological Diagnosis	
	Acute appendicitis n (%)	Unremarkable Appendix n (%)
Acute Appendicitis	51(59.30)	2(14.29)
Abscess/collection	22(25.58)	0(0.0)
Unremarkable	13(15.12)	12(85.71)
Appendix total	76(100)	14(100)

In terms of concordance between ultrasonogram findings and histopathological diagnosis, ultrasonography diagnosed acute appendicitis in 59.3% of patients who were later confirmed by histopathology, while 14.29% of patients with an unremarkable appendix were also diagnosed with acute appendicitis via ultrasound. Ultrasonography identified abscess or collection in 25.58% of cases, but no unremarkable appendix cases fell into this category. Additionally, 15.12% of patients had an unremarkable appendix according to ultrasound, aligning with histopathological findings in 85.71% of these cases.

Table 9: Sensitivity and specificity of Ultra-sonogram (n=100)

High-resolution Ultra-sonogram diagnosis	Histopathological Diagnosis	
	Positive	Negative
Positive	73 (TP)	2 (FP)
Negative	13 (FN)	12 (TN)
Sensitivity	84.9%	
Specificity	85.7%	
Positive Predictive Value	97.3%	
Negative Predictive Value	48.0%	

The sensitivity and specificity of high-resolution ultrasonography in diagnosing acute appendicitis were calculated based on histopathological findings. The ultrasonogram showed a sensitivity of 84.9%, meaning it correctly identified 73 true positive cases of acute appendicitis. The specificity was 85.7%, indicating that it correctly identified 12 true negative cases where the appendix was unremarkable. The positive predictive value was 97.3%, meaning that 97.3% of patients diagnosed with acute appendicitis via ultrasound were confirmed by histopathology. However, the negative predictive value was lower at 48.0%, indicating that only 48% of patients with a negative ultrasound result were confirmed to have no acute appendicitis upon histopathological examination.

DISCUSSION

The age range of the patients spanned from 15 to 60 years, with an average age of 28.571±1.202 years (mean ± SD). The majority of cases were observed in the 2nd and 3rd decades of life, accounting for 43% and 33%, respectively. Additionally, 13% of the patients were aged 31-40 years, 7% were aged 41-50 years, and 4% were aged 51-60 years. These findings align with several other studies, which identify appendicitis as primarily affecting younger individuals, though it can occur across all ages and genders [18,19]. In this study, the male-to-female ratio was 1.4:1, with no significant link between gender and the histopathological diagnosis of appendicitis. The slightly higher prevalence among males is consistent with the results of several other studies [19, 24]. In this study, 50% of patients experienced periumbilical pain that migrated to the right iliac fossa (RIF), 30% had pain localized to the right iliac fossa, 13% reported epigastric pain that shifted to the right iliac fossa, and 7% had pain throughout the entire abdomen. The migration of pain from the periumbilical area to the right lower quadrant was the most distinguishing aspect of the patient's history. Studies by Craig *et al.,* and Kazarian *et al.,* also found that the most common persistent symptom was abdominal pain localized to the right lower quadrant [25, 26]. In this study, all patients experienced abdominal pain, with 66% presenting with fever, 85% with anorexia, 65% with nausea, 53% with vomiting, 25% with constipation, and 13% with diarrhea as symptoms. The study revealed that the pulse rate was ≤100/min in 76% of patients and over 100/min in 24%. The temperature was normal in 15% of patients, between 98.6-100°F in 61%, and above 100°F in 24% of cases. Tenderness was localized in 76% and diffused in 24% of patients. Additional positive signs included muscle guarding (72%), pointing signs (82%), rebound tenderness (74%), Rovsing's sign (70%), the Psoas test (60%), and the obturator test (24%). A study by Khan *et al.,* found that the pulse was ≤90/min in 85% of patients and above 90/min in 15%, with temperatures around 100°F in 90% and above 100°F in 10%, pointing sign in 90%, rebound tenderness in 76%, and a positive Rovsing's sign in 78% of cases [27]. The appendix was positioned retrocecal in the majority (68%) of cases, with

28% in the pelvic position, 2% subcecal, and 3 cases each of appendicitis in the paracecal and post-ileal positions. Histopathological examination revealed acute appendicitis in 86% of patients, while the remaining 14% had a normal appendix. Thus, the diagnostic accuracy was 86%, with a 14% error rate or negative appendectomy. These findings align with several other studies that report an error rate of less than 15% [19, 28, 29]. Among the 76 patients diagnosed with acute appendicitis based on histology, 73 had the same diagnosis confirmed by a high-resolution ultrasound. Out of the 75 patients diagnosed with acute appendicitis via high-resolution ultrasound, 73 were confirmed histologically, while 2 had an unremarkable appendix. When histopathology was used to verify the ultrasound diagnosis of an unremarkable appendix in 25 patients, 13 were found to have acute appendicitis, and 36 had an unremarkable appendix. Therefore, the sensitivity and specificity of high-resolution ultrasound were 84.9% and 85.7%, respectively. These findings are consistent with a study by Ko *et al.,* which reported a sensitivity and specificity of 85.2% and 100%, respectively, for ultrasound [30].

Limitations of The Study

The study was conducted in a single hospital with a small sample size. So, the results may not represent the whole community.

CONCLUSION

Appendicitis is a disease of the young and can occur in participants of both genders. Histopathological diagnosis has no significant association with patient age or gender. Ultra-sonogram has high sensitivity and specificity ratio in diagnosing acute appendicitis and also has a high positive predictive value but low negative predictive value.

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