ORIGINAL ARTICLE

"COMPARATIVE ANALYSIS OF ULTRASOUND IN DIAGNOSING APPENDICITIS: A HISTOPATHOLOGICAL CORRELATION STUDY"

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Abstract

Introduction:
Ultrasound (USG) is a safe and cost-effective first-line imaging technique for the diagnosis of acute appendicitis. The objective of this study was to assess the diagnostic efficacy of ultrasound by correlating its findings with histopathological results.

Materials and Methods:
This retrospective observational study was conducted at the Bharat Ratna Late Shri Atal Bihari Vajpayee Memorial Government Medical College in Rajnandgaon, Chhattisgarh, India, from January 2022 to January 2024. The study encompassed 208 cases of suspected acute appendicitis. Ultrasound scores were determined based on specific sonological criteria and these scores were subsequently compared to histopathological findings to evaluate diagnostic accuracy, sensitivity, and specificity.

Results:
Out of a total of 208 cases, 190 underwent comprehensive ultrasonographic assessment followed

by histopathological examination. The study population was predominantly male, comprising 77.88% of the participants, with 33.17% of patients aged between 11 and 20 years. The retrocecal positioning of the appendix was identified as the most prevalent, occurring in 72.63% of cases. The USG demonstrated a sensitivity of 91.03%, a specificity of 87.37%, and an overall accuracy of 63.16% in the diagnosis of acute appendicitis. The kappa (κ) value was calculated to be 0.589, indicating a moderate level of agreement between the USG findings and the histopathological results. Furthermore, the study revealed variability in diagnostic accuracy contingent upon the ultrasound scoring system employed.

Conclusion:
Ultrasound is a valuable diagnostic tool for acute appendicitis. However, relatively low accuracy of the ultrasound scoring system indicates that,it should be utilized in conjunction with clinical judgment and, when appropriate, other diagnostic methods.

Key words – Appendicitis, Ultrasonography, Accuracy, Ultrasound Scoring System

Introduction:

Acute appendicitis is recognized as the most common abdominal surgical emergency worldwide, with age-standardized incidence rates varying from 53.8 to 1349.8 cases per 100,000 individuals [1]. The timely and accurate diagnosis of appendicitis is of paramount importance [2]. A missed or delayed diagnosis can result in increased morbidity and mortality due to complications such as perforation [3,4], while unnecessary removal of a normal appendix has also been associated with elevated mortality rates [5]. According to the American College of Radiology Appropriateness Criteria [7], contrast-enhanced computed tomography (CT) is the preferred imaging modality for diagnosing appendicitis in adults. In contrast, ultrasound (US) is recommended as the first-line imaging technique for pediatric and pregnant patients [8]. Although abdominal CT provides superior sensitivity, it is accompanied by high costs, limited availability in certain healthcare facilities, and potential risks, including iatrogenic ionizing radiation, allergic reactions to iodinated contrast media, nephrotoxicity, and prolonged hospital stays [6]. Conversely, ultrasound is regarded as a safer and relatively cost-effective alternative [10]. A meta-analysis comprising 18 studies has demonstrated that abdominal ultrasound (USG) exhibits significant diagnostic accuracy in patients with suspected acute appendicitis [9].
The present study was conducted to evaluate the diagnostic efficacy of ultrasound (USG) in Diagnosing Appendicitis performed at our institution, with particular emphasis on its sensitivity, specificity, and overall diagnostic accuracy. This assessment was achieved by correlating the findings from USG with histological diagnoses, which are considered the gold standard for the diagnosis of acute appendicitis.

Materials and Methods:

Study Design and study population:

This retrospective observational study aimed to evaluate the diagnostic efficacy of ultrasound in the diagnosis of appendicitis. The study was conducted over a two-year period, from January 2022 to January 2024, at the Department of Surgery, Bharat Ratna Late Shri Atal Bihari Vajpayee Memorial Government Medical College, Rajnandgaon, Chhattisgarh, India. The

primary outcomes assessed included diagnostic accuracy, sensitivity, and specificity, which were determined by correlating ultrasound findings with histological diagnoses.

The study population consisted of all patients presenting with right iliac fossa pain who were suspected of having acute appendicitis, spanning a wide age range from 5 to 80 years. The research included all cases of acute appendicitis that underwent appendicectomy, while excluding patients with specific complications such as appendicular phlegmon, appendicular abscess, recurrent appendicitis, cases of interval appendicectomy, and those with a history of previous appendicitis. All patients underwent abdominal ultrasound, during which appropriate sonologic scores were calculated. These scores included: anteroposterior diameter greater than 6 mm (score 1), non-compressible tubular structure (score 1), echogenic changes in the periappendicular fat (score 1), thickness of the appendicular wall greater than 2 mm (score 1), target sign (score 1), and presence of appendicolith (score 1), yielding a maximum total score of six [10]. The calculated ultrasound score was then correlated with the gold standard histopathological diagnosis.

Data Collection and Statistical Analysis:
Data were collected regarding patient demographics, duration of symptoms, comorbidities, prior abdominal conditions, results from physical and local examinations, laboratory tests, and ultrasound studies. The study employed the statistical software SPSS version 26 (IBM Corp., Armonk, NY) for data analysis, calculating sensitivity, specificity, positive predictive value (PPV), negative predictive value (NPV), diagnostic accuracy and appropriate cut-off for USG scores, with statistical significance set at $p < 0.05$.

Result:
This study conducted an analysis of 208 cases of acute appendicitis, with comprehensive demographic and diagnostic data collected from January 2022 to January 2024. Among the participants, 190 underwent a complete ultrasound (USG) assessment followed by histopathological examination. The study population was predominantly male, comprising 77.88% of the total cases, with 33.17% of the patients classified within the adolescent age group (11 to 20 years). The most frequently observed location of the appendix was retrocecal, accounting for 72.63% of cases. Intraoperative findings indicated that 65.79% of the appendices were inflamed and edematous, while appendicular perforation was noted in 20.53% of the cases. Histopathological examination confirmed the diagnosis of acute appendicitis in 93.42% of cases. In contrast, 3.29% of appendices were determined to be normal, while additional findings included carcinoid tumors (1.32%) and mucinous cystadenoma (1.32%). [Table-1]
Ultrasound (USG) exhibited a sensitivity of 91.03%, specificity of 87.37%, and an accuracy of 63.16% in the diagnosis of acute appendicitis. The positive predictive value (PPV) was recorded at 93.42%, and the negative predictive value (NPV) was 63.16%. The κ value was calculated to be 0.589, indicating moderate agreement between USG and histopathological results. The p-value was found to be less than 0.0001, suggesting a statistically significant correlation between USG findings and histopathological outcomes. [Table-2]

The study further evaluated the diagnostic accuracy of the ultrasound scoring system, which exhibited variability based on the assigned score. At a score of '2' the sensitivity was recorded at 83.72%, while the specificity was 88.88%. Conversely, at a score of '3' the sensitivity decreased to 12.50%, whereas the specificity increased to 96.10%. [Table-3]

Table1:Demographic and diagnostic features of the participants

Variables	**Frequency in number**	Percentage
Age group (in years)		
5 yer--10	18	8.65
11 year -20	69	33.17
21-30	54	25.96
31-40	29	13.94
41-50	18	8.65
51-60	11	5.28
>61	9	4.32
Gender		
Male	162	77.88
Female	46	22.11
Total USG	**190***	
Diagnosed normal or other than appendicitis	38	
Diagnosed Appendicitis	152	
Position of appendix		
Retrocaecal	138	72.63
Pelvic	36	18.94
Subcaecal	8	4.21
Pre-ileal	6	3.15
Post-ileal	2	1.05
Intraoperative findings		
Inflamed and oedematous appendix	125	65.78
Appendicular perforation	39	20.52
Faecolith	13	6.84
Gangrenous appendix	10	5.26
Mucocele	3	1.57
Histopathological findings		
Acute appendicitis	174	93.42
Normal appendix	7	3.28
Carcinoid tumour	4	1.31
Mucinous cystadenoma	3	1.31
Granulomatous appendicitis	2	0.65

Table2: Conformity of the USG and histopathology results of the study patients

Variables		**Histopathological diagnosis**		**Total**
		Appendicitis (positive)	**Normal or other than appendicitis (negative)**	
		N	N	
USG diagnosis	**Appendicitis (positive)**	142	10	152
	Normal or other than appendicitis (negative)	14	24	38
Total		174	16	190
Statistical Statistical analysis Result		Sensitivity		91.03%
		Specificity		87.37%
		Accuracy		63.16%
		PPV		93.42%
		NPV		63.16%
		κ		0.589
		p-value		<0.0001

Table 3: **Sensitivity and specificity of the ultrasonography score**

USG SCORE		**Positive On Histopathology**	**Negative On Histopathology**	**Total**	**Sensitivity (%)**	**Specificity (%)**	**p-value**
Score "0" (Negative on USG)		14	24	38	91.10	70.51	--
Positive on USG	**Score "1"**	39	4	43	73.59	85.71	3.2
	Score "2"	72	3	75	83.72	88.88	0.59
	Score "3"	29	2	31	67.44	92.30	2.1
	Score "4"	2	1	3	12.50	96.10	0.79
Total		156	34	190			

Discussion:

The findings of this study highlight the significance of ultrasound (USG) as a diagnostic tool for acute appendicitis, particularly in settings with limited resources. The demographic characteristics of the study population, which was predominantly male (77.88%) and included a substantial proportion of adolescents (33.17%), align with established epidemiological trends associated with acute appendicitis. This condition is known to be more prevalent among younger males, a trend corroborated by existing literature [12,13,14]. In recent years, ultrasound has emerged as a vital instrument in the diagnostic process, particularly due to its non-invasive

nature, absence of ionizing radiation, and relative accessibility. Numerous studies have validated the efficacy of USG in diagnosing appendicitis, especially in pediatric and adolescent populations, where minimizing radiation exposure is critical [15,16,17]. Recent research has concentrated on enhancing the diagnostic accuracy of USG through various methodologies, including the development of scoring systems and the application of advanced ultrasound techniques [18,19,20]. A meta-analysis conducted by Arruzza et al. in 2022 reported pooled sensitivity and specificity of USG for acute appendicitis at 82.1% and 85.9%, respectively [21], which closely correspond to the sensitivity (91.03%) and specificity (87.37%) observed in the current study. The accuracy of ultrasound can be affected by factors such as the anatomical position of the appendix and the proficiency of the operator [23,24]. In the present study, the majority of appendices were found to be retrocecal (72.63%), a position recognized as more challenging for ultrasound visualization. This observation is supported by multiple studies indicating that retrocecal appendicitis can diminish the sensitivity of ultrasound, thereby necessitating careful consideration of alternative imaging modalities, such as computed tomography (CT), in ambiguous cases [23,24,25,26,27]. The introduction of scoring systems to standardize ultrasound interpretation represents a significant advancement in the field. The Alvarado score, although primarily clinical, has been integrated with ultrasound findings to enhance diagnostic accuracy [28,29,30]. Recent studies, including those by Bhardwaj et al. (2023) and Jain S et al. (2022), have proposed modified scoring systems that incorporate ultrasound parameters, demonstrating potential in increasing both the sensitivity and specificity of appendicitis diagnosis [18,31]. However, the present study revealed that the overall accuracy of the USG scoring system was 63.16%, with sensitivity decreasing and specificity increasing at higher scores. This inverse relationship suggests that while elevated scores may confirm the diagnosis with greater confidence, they may overlook cases presenting with lower scores, underscoring the necessity for comprehensive clinical evaluation. Furthermore, the moderate κ value (0.589) observed in this study indicates only fair agreement between USG and histopathological findings, suggesting opportunities for improvement in diagnostic protocols and the potential advantages of combining USG with other diagnostic modalities.

This study advocates for the sustained utilization of ultrasound as the primary imaging modality for suspected appendicitis, particularly in pediatric populations and regions with restricted access to computed tomography (CT). It is imperative for clinicians to recognize the limitations of ultrasound, particularly in cases of retrocecal appendicitis or when low scoring is observed. Future research endeavors should focus on enhancing ultrasound scoring systems and integrating ultrasound with complementary diagnostic tools to augment diagnostic accuracy.

Limitations:
The study's limitations encompass its retrospective design, which may introduce selection bias, as well as the inherent variability in the skill levels of ultrasound operators, potentially impacting the consistency of the results. Furthermore, the relatively low accuracy of the ultrasound scoring system indicates that, although it serves as a valuable tool, it should be utilized in conjunction with clinical judgment and, when appropriate, other diagnostic modalities.

Conclusion: This study highlights the significance of ultrasound in the diagnosis of acute appendicitis. The results advocate for the sustained application of ultrasonography in clinical

practice, especially when combined with other clinical findings and diagnostic approaches. Furthermore, the relatively low accuracy of the ultrasound scoring system indicates that, although it serves as a valuable tool, it should be utilized in conjunction with clinical judgment and, when appropriate, other diagnostic methods.

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