

The Role of ultrasound in the diagnosis of acute appendicitis

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Purpose: To evaluate the diagnostic performance of ultrasonography (U/S) for the diagnosis of appendicitis in pediatric and adult populations

Abstract: Introduction: Acute appendicitis (AA) is a disease with a high prevalence. requiring rapid and accurate action to confirm diagnosis and prevent its complications. It is the most common abdominal surgical emergency and has a lifetime prevalence of about 7% [1]. Although two tools are used to diagnose acute appendicitis: ultrasound and CT imaging the later not used in our community for cost effectiveness and complain pf investigator. The end point of this study was to verify the diagnostic accuracy (DA) of ultrasound imaging in the diagnosis of acute appendicitis with respect to intra-operative finding and the clinical and laboratory findings in young adult and in the pediatric populations.

Methods: We considered all the appendectomies for acute appendicitis performed between 1 January 2015 and 1 January 2019 at Alnuman teaching hospital. We evaluated clinical symptoms, laboratory findings, ultrasound findings, intra-operative signs. In the study we compared the ultrasound and intra-operative findings and then compared these with the clinical and laboratory diagnosis.

Results: In a comparison of diagnostic accuracy (DA), the difference between clinical and ultrasound examinations was statistically significant for U/S they were 54%, 38%, 25% in pediatric adult female and adult male respectively while the clinic with laboratory were 68%, 50%, 67% in same age group respectively

Conclusion: We found while blood cells count were non-diagnostic of acute inflammation but rather as indicators of the severity of the inflammatory process. We also agree with the authors who proposed the incorporation of ultrasonography into routine practice in the diagnosis of acute appendicitis, but only and exclusively to support other diagnostic procedures specialty in adult female and preferably indicated in all pediatric. Nevertheless, clinical examination of patients with suspected acute appendicitis is still the best diagnostic procedure available to us till now.

Keywords: Ultrasound, Acute appendicitis, use of image diagnosis of appendicitis, pediatric, pediatric appendicitis

1. INTRODUCTION:

Acute appendicitis is the most common cause of acute abdomen in adolescents [2-3], with an overall incidence of 7% as reported in the literatures [5]. An important predictor in the clinical diagnosis of acute appendicitis in the classic migration of pain described by Murphy in 1905 [4]; according to the medical literature, this alone has a diagnostic accuracy of up to 95% [6-8]. The positivity of McBurney's sign increases suspicion of acute appendicitis [7]. If presentation is typical, the diagnosis of acute appendicitis is based on clinical and laboratory finding with no need for any further investigations. There are several scoring systems used as aids in diagnosis of AA, alverado score (MANTREEL) and the RIPASA score which is used in Indian, the former is mainly used widely, and it is mainly applied in our study.

In 35-40% of cases the clinical features are non-specific and unclear [8]. According to some studies, the discriminatory power of clinical and laboratory findings alone is not strong enough to diagnose acute inflammation of the appendix [9], and the use of U/s as a first-level diagnostic tool is essential for early diagnosis [10].

The use of ultrasonography U/S to visualize the appendix was first described by Deutsch and Leopold in 1981. and in 1986 Puy alert described the use of graded compression during

Appendicitis aetiology and prevalence:

In children and in adults in adult's acute appendicitis (AA) is a common surgical emergency condition occurring at any age but usually between 10 and 20 years [13,14]. There is a male preponderance. With a male to female ratio of 1.4 [13-14]. The overall lifetime risk is about 6.7% for females and 8.9% for males in the USA [15]. We do not know

Clinical diagnosis of appendicitis:

Clinical signs and symptoms: acute appendicitis AA might be called simple AA [13]. In the absence of gangrene, perforation or abscess around the inflamed appendix, or complicated AA when perforation, gangrene or peri-appendicular abscess are present.

Abdominal pain is the primary presenting complaint, followed by vomiting with migration of the pain to the right iliac fossa described first by j Murphy in 1904 [17]. However, this classical presentation is quite often absent, either due to variation in the anatomic position of the appendix or the age of the patient, with atypical presentations seen often in infants and elderly patients [13].

Laboratory markers: A good review of laboratory markers for the diagnosis of AA is provided by DJ Shogilev et al. [18]. The degree of white blood cell elevation, the value of C-reactive protein, the proportion of polymorph nuclear cells, a history of fever and other factors have been studied extensively for the diagnosis of AA, but lack sufficient specificity either alone or in combination. On the contrary, the absence of all of these laboratory parameters can potentially rule out the diagnosis of AA [18] ultrasound examination in the diagnosis of pate with suspected acute appendicitis (12) the cause of AA, but there are probably many contributing factors. The primary case is probably luminal obstruction, which may result formfecoliths, lymphoid hyperplasia, forcign bodies parasites and primary neoplasm or metastasis [16].

Scoring system: Many scoring system" (CSS) have been developed to assist clinicians in appropriately stratifying a patient's risk of having appendicitis. An excellent overview is provided by G Thompson [19] As these scores are quite often implemented in the method section of studies on the diagnostic performance of imaging techniques in patients with a clinical suspicion of acute appendicitis, knowledge of the most popular scores is mandatory these are Alvarado score introduced by Alvarado in 1986and sometimes referred as the MANTRELS score (acronym of the eight criteria). And the paediatric appendicitis score (PAS) or Samuel score, reported by Samuel in 2002 [19]. The Alvarado score has been reported in numerous studies in paediatric and adult patients with a suspicion of AA.

The Alvarado score was calculated retrospectively in study population of 119 adults with a suspicion of AA and non-visualization of the appendix in an otherwise normal US examination followed by computed tomography (CT) within 48 hours [20]. No patient (n=49) with an Alvarado score ≤ 3 had appendicitis, compared to 17% (12/70) patients with an Alvarado score ≥ 4 [20]. The authors conclude that patients with a non- visualized appendix with an otherwise normal US examination and an Alvarado score ≤ 3 do not benefit from a CT study. In a paediatric study population with a suspicion for AA, UIS was combined with a clinical assessment using the PAS [21]. The negative predictive value (NPV) of U/S decreased with increasing PAS-based risk assessment. The authors recommend serial U/S examinations or further imaging when there is discordance between U/s and PAS-scores

Real-time empression ultrasound: Real-time compression US was first introduced by Puylaert in 1986 [12- 23]. Over the last 30 years, this technique has been extensively studied and improved (48). Although the development of US technique has led to dramatic improvements in contrast, spatial and temporal resolution, U/S examination technique and US signs of appenddicitis in real-time US have undergone only slight evolution. Graded-compression US is performed in a step visualization of the appendix [14-16]. Recently it has been shown that the diameter of the normal appendix (mean antero-posterior diameter) 4.4 ± 0.9 mm, and the mean transverse diameter 5.1 ± 1.0 mm) does not change with age and is normally distributed in children [24]. To date, there are only few reports on the use of U/S elastography techniques in diagnosing AA [25-26].

The same holds true for contrast-enhanced US (CEUS) [27- 28]. Besides, case reports in the largest series of 50 patients with suspected acute AA, L Incest et al. [27] scored hyperemia in the wall of the appendix optimize and prominent peripheral vascularity as seen by CEUS positive for AA. Director and, indirect Us, Doppler and CEUS signs of AA both in the pediatric and adult patient are summarized in Tables I and 2. Ultrasound imaging examination of choice for patients admitted to the emergency department with acute inflammation [49-50]. CT imaging has been found to have better diagnostic accuracy than ultrasonography, but is also more expensive [25-28-29]. It also delivers a of radiation & should not be used in children or in childbearing aged women. End point of this study was to verify the accuracy of ultrasound imaging in the diagnosis of acute appendicitis with respect to intra-operative observations and the respective clinical and laboratory diagnosis of the cases.

All the operations were performed by nine specialized surgeons with similar experience in general surgery in the study we compared the ultrasound and intra- operative findings and then compared these with the respective clinical and laboratory data.

Table 1: Alvarado score (score ≥ 7 = high-risk for appendicitis) and paediatric appendicitis score (Samuel score: adopted according to G. Thompson [19]. RLQ right lower quadrant of the abdomen

Alvarado score (MANTRELS)		Paediatric appendicitis score (Samuel score)	
Diagnostic criteria	Value	Diagnostic criteria	Value
Migration pain to RLQ	1	Migration pain to RLQ	1
Anorexia/acetone in urine	1	Anorexia	1
Nausea-vomiting	1	Nausea/emesis	1
Tenderness in RLQ	2	Tenderness in RLQ	2
Rebound pain	1	Cough/percussion tenderness	2
Temperature 37.3°C	1	Pyrexia (not defined)	1
Leukocytosis ($>10 \times 10^3/\text{L}$)	2	Leukocytosis ($>10 \times 10^3/\text{L}$)	1
Leucocyte shift to left ($>75\%$)	1	Neutrophilia	1
Total score	10	Total score	10

Table 2: Direct and indirect (secondary) signs of acute appendicitis in graded-compression, real-time US, color Doppler and contrast-enhanced US (CEUS; adopted according to references 14-16-27 and 28)

Real-time US signs of acute appendicitis	
Direct signs	Indirect signs
Non-compressibility of the appendix Perforation: appendix might be compressible	Free fluid surrounding appendix
Diameter of the appendix $>6\text{ mm}$	Local abscess formation
Single wall thickness $\geq 3\text{ mm}$	Increased echogenicity of local mesenteric fat
Target sign: Hypoechoic fluid-filled lumen Hyperechoic mucosa/submucosa Hypoechoic muscular is layer	Enlarged local mesenteric lymph nodes
Appendicolith: hyperechoic with posterior shadowing	Thickening of the peritoneum
Colour Doppler and contrast-enhanced US: Hypervascularity in early stages of AA Hypo- to a vascularity in abscess and necrosis	Signs of secondary small bowel obstruction

2- METHODS

This retrospective study was performed at Alnuman teaching Hospital general surgery Unit. all the appendectomies for acute appendicitis performed between 1 January 2015 and 1 January 2019 were evaluated. The cohort comprised a total of 629 patients adult female patient number was 342, adult male patient number was 179 and lastly the pediatric patient total number was 108 Of these, the following were excluded from the study: A patients in whom a certain diagnosis was made on the basis of clinical and laboratory findings and surgery was performed without pre-operative imaging, and all patients with particularly serious clinical and biohumoral symptoms. In the latter group of patients, ultrasound scans were not performed prior to surgery.

The following parameters were evaluated: clinical symptoms (pain, nausea, vomiting, body temperature, McBurney's sign, guarding in the right iliac fossa), laboratory findings (WBC), ultrasound findings (visualization of the appendix, appendiceal peristalsis, appendiceal wall thickening compression of the viscus by application of the probe, periappendiceal effusion and lymph adenopathy), intra-operative signs (appendiceal erythema-edema, appendiceal phlegmon, gangrene of the appendix, perforation, gangrene and effusion), For each group, a final overall rating of the "typicality of findings" for acute appendicitis was assigned.

Typical clinical symptoms include fever and localized right iliac fossa pain, with or without nausea and vomiting. As regards laboratory variables, typical symptoms included a WBC of $>13,000$ and Ultrasound variables included visibility of the appendix with thickening of the walls, or the simultaneous presence of two or more of the following secondary characteristics: adipose inflammation, periappendiceal lymphadenopathy, periappendiceal effusion.

For the ultrasound diagnosis only, the "doubtful finding" parameter was included when just one of the secondary signs was present. Intraoperatively, a positive diagnosis of acute appendicitis was made if the surgeon identified one of the following signs: appendiceal erythema, erythema-edema, phlegmon, necrosis, gangrene, frank perforation and/or foreign body obstruction

3- THE RESULT:

Demographic characteristics of our study sample are described in Table 3: the patients were statistically comparable, the total number of adult female were 342 cases minimum age was 17 years and maximum age was 55 years with average age was 27.7 years old and stander deviation SD was ± 7.3 , the total adult male were 179 cases minimum was 17 years to maximum 66 years with the average age was 25.8 and stander deviation SD was ± 6.8 , lastly the pediatric age group from 6 years to 12 years was selected the average age was 9.8 years and stander deviation+ 1.7.

Table 4,5, and 6 shows the results in terms of the "typical findings" of the acute appendicitis at time of operation in adult female, adult male and pediatric age group respectively where in term of statistical analysis (table 4) the U/S was able to diagnosed 95 case of acute appendicitis (true positive in operative finding) from total 232 case diagnosed with use of U/S first where the reminder 137 case were normal appendix at time of operation and the cause of right iliac fossa pain due to other gynecological condition like ovarian problems (mean 116 and stander deviation 296) never the less the U/S first diagnosis is still significant in comparison of clinical and laboratory diagnosis of acute appendicitis in adult female (p value < 0.01), in the fact the former has ability to rule out the most gynecological conditions.

In other hand (table 5) the U/S first diagnosis in acute appendicitis in adult male was able to confirm 34 cases from 74 cases total and the 44 cases was normal appendix at time of operation (false negative) the mean was 37 and stander deviation SD 9.9 however the clinical and laboratory first diagnosis was more certain with only 15 cases true negative (normal appendix) from 105 cases of total that is mean the U/S first was less significant than clinical and laboratory in diagnosis of acute appendicitis in adult male.

The table 6 compare U/S first with clinical and laboratory diagnosis of acute appendicitis in pediatric age group, where the former was highly useful and significant in diagnosis of acute appendicitis in this aged group probably the fact of thin abdominal wall and less intra-abdominal fat s the U/S first was able to detect (true positive) 40 cases from 55 cases in total, (mean was 37 and stander deviation 4.24) with positive predictive value of us was 72%.

Table 7 and 8 shows the definitions and the stratification of the specificity, sensitivity positive predictive value, negative predictive value and diagnostic accuracy in term of statistical analysis of U/S first and clinical and laboratory diagnosis of acute appendicitis. if we have a look to table 7 we find that the specificity and sensitivity of U/S in diagnosis of acute appendicitis in paediatric were higher than other group 55% and 54 % respectively with diagnostic accuracy reached 54 % and positive predictive value of 72 %.the specificity and sensitivity of U/S in adult female group was less 20 % and 55 % respectively with positive predictive value of 40 % reached but the diagnostic accuracy were 38 %.the lowest specificity and sensitivity (25 %, 25.4 % respectively) were identified in adult male group with positive predictive value of 40 % and diagnostic accuracy was only 25 %..

In other hand the table 8 show the fact of clinical and laboratory diagnosis of acute appendicitis in the term of statistical analysis as follow: the highest specificity and sensitivity 67 % and 67 % respectively were in pediatric aged group with positive predictive value 64% and highest negative predictive value 72% these will bring about the diagnostic accuracy 68% of clinical and laboratory diagnosis of acute appendicitis in pediatric age group. the second significances of clinical and laboratory was find in adult male group with highest positive predictive value of 85% were reached and with the diagnostic accuracy of 67 %. while in adult female group the specificity was highest 73% and with lowest sensitivity 35% however the diagnostic accuracy was 50% with positive predictive value of 69% were reached. From all above, In a comparison of diagnostic accuracy (DA), the difference between clinical and ultrasound examinations was significant in pediatric aged group and adult male group and it were not significant in adult female group.

Table 3: Patient baseline characteristics

Gender	Total number	Average age(years)	Stander deviation
Adult female	342	27.7	7.3
Adult male	179	25.8	6.8
Pediatrics	108	9.8	17

Table 4: Acute appendicitis in adult female:

Variable	Operative finding +ve	No operative finding	Total
Us diagnosis	95	137	232
Clinic and lab	76	34	110
Total	171	171	342

Correlation is significant at the 0.01 level.
Us diagnosis: Mean =116/ Stander deviation SD-29.6
Clinic and lab: mean = 55/ SD-29.6

Table 5: Acute appendicitis in adult male:

Variable	Operative finding +ve	No operative finding	Total
Us diagnosis	30	44	74
Clinic and lab	90	15	105
Total	120	59	179

Correlation is significant at the 0.01 level.
Us diagnosis: mean = 37/ SD=9. 9..Clinic and lab: mean= 52.5 / SD=53