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Diagnosis of acute appendicitis by modified Alvarado score vs. ultrasound based on histopathological findings: A comparative study

Baderkhan Saeed Ahmed[1], Azhy Muhammed Dewana[1], Balen Salahaddin Muhammed[1], Tavga Omer Jaffar[2], Nyan Saeed Omar[3] , and Amanj Jalal Namq[1]

[1]Hawler Medical University-College of Medicine-Department of Surgery-Erbil-Iraq
[2]Raparin teaching hospital, Erbil directorate of health, ministry of health-Erbil-Iraq
[3]Hawler Medical University-College of Medicine-Department of basic sciences. -Erbil-Iraq

**Corresponding author*: E-mail: baderkhan.saeed@hmu.edu.krd

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Acute appendicitis, modified Alvarado score, Comparative study.

ABSTRACT

Background: Acute appendicitis commonly causes emergency surgery. Clinical examination accuracy ranges from 71-97%; despite ultrasound diagnostic improvements, accuracy depends mainly on operator experience. This study uses a modified version of the Alvarado score, excluding one laboratory finding (shift to the left of neutrophil maturation). As differential count is not routinely undertaken in the study site (Erbil), patients were scored out of 9 rather than 10 points. This study compares the diagnostic accuracy of ultrasound and modified Alvarado score in the diagnosis of acute appendicitis, to reduce appendicitis mortality and morbidity, and reduce rates of negative appendicitis.

Methodology: The study design was a prospective cross-sectional comparative study, which took place in the Surgery, Radiology and Histopathology Department of Rizgary Teaching Hospital and Rozhalat Emergency Hospital, Erbil, from January 2019 to December 2021. All patients who presented to the emergency room with signs and symptoms of acute appendicitis were clinically evaluated. Patients who had a modified Alvarado score > 8 were considered positive for modified Alvarado, and those scoring 6-7 were considered negative for modified Alvarado and were considered for ultrasound examination; among the latter, those with positive ultrasound results were included in the study.

Results: Among the 468 patients, 257 (54.9%) were male and 211 (45.1%) were female (1.22:1 male: female ratio), with a mean age of 23.45 ± 2.1 years (ranging from 12 to 56 years). Modified ultrasonography has a sensitivity of 82% and an accuracy of 79.9%; the modified Alvarado score had a sensitivity of 95.2% and an accuracy of 87%. There was no association between the mean age of male and female patients with the histopathological results. The most commonly affected age group was the cohort 21-30 years (51.7% of all patients). The number of patients with positive histopathology was 411; negative histopathology was recorded for 57 patients, with no association between histopathological results and gender. There was a significant association between symptoms (cough signs, localized tenderness signs, and pointing signs) and positive histopathology findings.

Conclusion: Modified Alvarado score has higher sensitivity than ultrasound, while ultrasound has a higher specificity. Neither tool is superior to the other, nor both need to be used together to reduce negative appendectomy rates.

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INTRODUCTION

The vermiform appendix is a worm-like tubular structure that protrudes from the blind end of the cecum.[1] At birth, the appendix is short and wide at its junction with the cecum, but the differential growth of the cecum makes the structure tubular around the age of about two years. During early childhood, the continued growth of the cecum usually rotates the appendix, whereby it can occupy one of the following positions (in descending order of prevalence): retrocecal and retrocolic (74%), pelvic (21%), subcecal (1.5%), preileal (1%), or paracecal (2%). The length of the appendix varies from 2-20 cm, averaging about 9 cm; it is longer in children than in adults and may atrophy and shrink after mid-adult life.[2]

Acute appendicitis is one of the most common causes of emergency surgery, and the condition poses a 6-7% risk to life. Appendicitis-related perforations associated with increased morbidity and mortality may progress, thus surgeons are more likely to intervene when the diagnosis is probable and expected.[3] The accuracy of clinical examination has been shown to vary from 71-97% and varies widely depending on the experience of the examiner. However, due to non-recognized perforations of the appendix, surgeons have traditionally accepted a negative appendectomy rate of 20% (i.e., clinically unnecessary removal of the normal appendix in patients with other causes).[4,5] The rate of negative appendectomy in men is generally less than 20%. Young women, however, usually suffer from acute gynaecological diseases that mimic acute appendicitis, and they suffer a disturbing negative appendectomy rate, reaching 34-46% among ovulating women.[6,7] An accurate diagnosis is necessary for patients with an acute abdomen, as 7% of the general population are likely to suffer from acute appendicitis during their lifetime, with peak incidence during the age range of 10-30 years.[8] Failure to make an early diagnosis can lead to serious consequences and complications, such as peritonitis, abdominal abscess, and even death.[9] Despite technological developments, the diagnosis of acute appendicitis is based primarily on the clinical evaluation of the patient, which includes a detailed medical history with a physical examination, followed by blood testing for leukocytosis. A simple x-ray is rarely recommended in this context. Ultrasound is a repeatable, non-invasive option among imaging modalities that avoids exposure to ionizing radiation (such as that involved in CT scans) and is cost-effective.[10,11] Although ultrasound has improved the diagnosis of appendicitis, its accuracy is highly operator-dependent. Furthermore, abdominal CT carries a risk of radiation exposure and increases the cost of treatment.[12] Most surgeons tend to rely on an abdominal ultrasound followed by a CT scan for an objective diagnosis.

The Alvarado scoring system has been used since 1986 among adult surgical patients.[13,14] Modified Alvarado Scoring System (MASS) was developed by omitting the left shift of leukocytosis from the Alvarado Scale. Taking into consideration that counting the white blood cell (WBC) differentials is not routine in many laboratories.[15,16] Ultrasound has also been shown to be highly sensitive and specific for the diagnosis of other conditions that cause right lower quadrant pain, in addition to acute appendicitis.[17] The rationale of this study is to compare the diagnostic accuracy of ultrasound and MASS score in the diagnosis of acute appendicitis, to reduce appendicitis mortality and morbidity, and to reduce rates of negative appendectomy. The outcomes of this study indicate that neither method is superior to the other, but both may be used for optimum treatment.

METHODS

The study design was a prospective cross-sectional comparative study, conducted in the Radiology, Surgery and Histopathology Department of the Rizgary Teaching Hospital and Rozhalat Emergency Hospital in Erbil, from January 2019 to October 2021. All patients who presented to the emergency room with signs and symptoms of acute appendicitis were clinically evaluated, and those who had a MASS score > 8 were considered positive for MASS, and those among 6-7 were considered negative for MASS, and were considered for ultrasound examination; subsequently, those with a positive diagnosis of appendicitis based on their ultrasound results were included in the study. MASS scores the signs, symptoms and complete blood picture based on the score (from a total of nine) based on the following: migration of pain to right {1}, nausea {1}, anorexia {1}, tenderness in right iliac fossa {2}, rebound tenderness {1}, elevated temperature {1}, leukocytosis {2}. All included patients underwent preoperative ultrasound (regardless of the days of menstruation in women). For the abdominal ultrasound scanning of patients, Siemens type G50 version 2011, Philips type HDXE version 2010, and Medison type SA8000 version 2009 were used. The transabdominal examination was performed with patients lying on their backs using the curved probe, with a low frequency of 3-4 MHz and a high-frequency linear probe of 6-9 MHz For the pelvic ultrasound, the patients were inspected with the urinary bladder sufficiently expanded to displace the small bowel from the view, and to give an acoustic window, using a 3.5 MHz test to detect any anomalies. The right iliac fossa was inspected with a high 7.5 MHz frequency probe to see the right common iliac artery, vein, and psoas muscle for localization of the appendix, by checking the area in transverse, longitudinal, and oblique positions, to see inflammation or any other anomalies (other than appendicitis). All patients who had one of the following ultrasound findings on

ultrasound examination were considered ultrasound positive for appendicitis:

1. A non-compressible, blind-ending, non-peristaltic tubular structure of more than 6 mm in transverse diameter in the vicinity of the right iliac fossa.
2. Probe tenderness.
3. Free intra-peritoneal fluid.
4. Increased peri-appendiceal fat echogenicity.
5. Presence of appendicolith.

All the patients with either positive ultrasound findings or MASS scores were included in the study and were sent to the surgical department for voluntary appendectomy. Patients with appendicular mass/abscesses were excluded from the study. The removed appendix was sent for histopathological examination in all cases, and the histopathological reports were collected and entered in an organized proforma, which included full history with clinical examination (signs and symptoms), and results of laboratory examination (MASS score) and ultrasound findings. Positive and negative appendices on histopathology were characterized by a normal-looking appendix and absence of acute inflammation on histopathology (negative), or appendices that appeared with acute inflammatory changes (positive).

Data were collected with appropriate informed consent. Participants were informed about the nature of the study and the voluntary nature of their participation, the right to withdraw at any time, and that their healthcare services would not be affected. All data were entered and analyzed utilizing SPSS version 23. This whole process of patient selection and data collection was done with permission from the Ethical Committee of Hawler Medical University (College of Medicine).

RESULTS

Among 468 patients of both genders included in the study, 257 (54.9%) were male and 211 (45.1%) were females; the male: female ratio was thus 1.22:1. The mean age of patients was 23.45 ± 2.1 years, ranging from 12 to 56 years (Figure 1). Their mean MASS score was 7.9 ± 1, with a maximum score of 9 and a minimum score of 7.

Ultrasound findings revealed that 433 (92.5%) patients had an appendix with a diameter >6 mm; 219 (46.8%) had surrounding free fluid; 423 (90.38%) had peri-appendicular fat, and 107 (22.86%) had appendicolith.

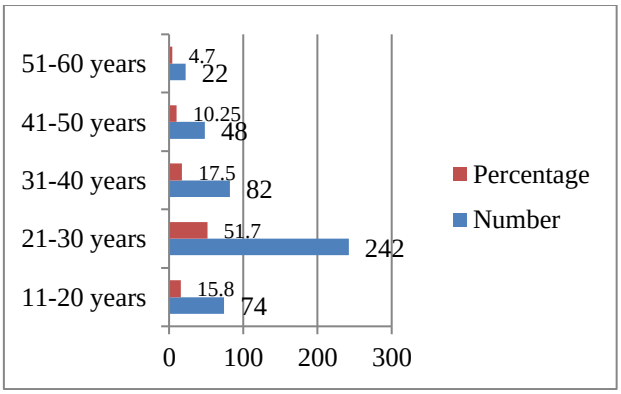

Figure 1: Age distribution of patients
Source: Authors

Table 1 shows the true positive, false positive, false negative, and true negative rates for both ultrasound and MASS scores. The sensitivity of ultrasonography was found to be 82% while the sensitivity of the MASS score was more than 95.2%. Likewise, the diagnostic accuracy of ultrasonography was 79.9% and that of the MASS score was 87%, as shown in Table 2.

Table 1: Comparison of ultrasonography with histopathology findings

	Histopathology Positive	Histopathology Negative
Ultrasonography		
Positive	337 (72%)	20 (4.3%)
Negative	74 (15.8%)	37 (7.9%)
MASS Score		
Positive	384(82%)	42(9%)
Negative	19(4%)	23(5%)

Source: Authors

There were no significant differences between patients with positive and negative histopathology findings regarding presenting symptoms (anorexia, nausea, vomiting, diarrhoea, generalized abdominal pain, migratory pain to RIF, peri-umbilical abdominal pain, and fever), as shown in Table 4. There is no association between the mean age of male and female patients with the histopathological results. The most commonly affected age group was 21-30 years (51.7% of total patients). The number of patients with positive histopathology was 411 patients; negative histopathology was noted for 57 patients, who had no association between histopathological results and gender (Table 3).

Table 2: Diagnostic variable of ultrasonography and MASS score

Diagnostic Variables	Ultrasonography	MASS Score
Sensitivity; TP/(TP+FN)	82%	95.2%
Specificity; TN/(TN+FP)	65%	35%
Positive Predictive Value; TP/(TP+FP)	94.3	90
Negative Predictive Value; TN/(TN+FN)	33.3	54.8
Diagnostic Accuracy; (TP+TN)/All Patient	79.9%	87%

Source: Authors

Table 3: Comparison of mean age of patients according to gender and histopathological results

Variables		No.	Mean
Gender	Male	224	22.51
	Female	211	24.56
Histopathology	Positive	401	23.68
	Negative	34	21
Total		435	23.49
Age range: 12-56 years			

Source: Authors

Table 4: Association between the histopathological result and symptoms

Symptom		Histopathology			
		Positive		Negative	
		No.	%	No.	%
Anorexia	Yes	366	92	32	8
	No	45	64.3	25	35.7
Nausea	Yes	217	86.1	35	13.9
	No	194	89.8	22	10.2
Vomiting	Yes	75	85.2	13	14.8
	No	336	88.4	44	11.6
Diarrhoea	Yes	58	78.4	16	21.6
	No	353	89.6	41	10.4
Migratory RIF pain	Yes	385	90.8	39	9.2
	No	26	59.1	18	40.9
Generalized abdominal pain	Yes	187	89	23	11
	No	224	86.8	34	13.2
Peri-umbilical pain	Yes	253	87.5	36	12.5
	No	158	88.3	21	11.7
Dysuria and frequency	Yes	229	87.4	33	12.6
	No	182	88.3	24	11.7

Source: Authors

There was a significant association between cough, localized tenderness, and pointing physical signs and patients with positive histopathology findings. There were no significant differences between patients with positive histopathological findings and those with negative findings regarding the physical signs of fever, rebound tenderness, Rovsing's sign, psoas sign and obturator sign (Table 5).

Table 5: Association between histopathological results and physical signs

Physical Signs		Histopathology			
		Positive		Negative	
		No.	%	No.	%
Fever	Yes	228	93.82	15	6.17
	No	212	94.2	13	6.77
Cough sign	Yes	308	96.25	12	3.75
	No	118	79.72	30	20.3
Localized tenderness	Yes	366	94.1	23	5.9
	No	58	73.4	21	26.6
Rebound tenderness	Yes	325	91.03	32	8.96
	No	98	88.28	13	11.71
Rovsing's sign	Yes	131	90.97	13	9.02
	No	203	90.71	31	9.56
Psoas sign	Yes	79	92.94	6	7.1
	No	342	89.3	41	10.7
Obturator sign	Yes	46	100	0	0
	No	376	89.1	46	10.9
Pointing sign	Yes	247	100	0	0
	No	178	80.5	43	19.45

Source: Authors

DISCUSSION

Acute appendicitis remains a common surgical emergency condition posing critical diagnostic challenges for the clinical judgment of professionals, particular less experienced surgeons who are frequently compelled to confirm a diagnosis and initiate surgical proceedings for emergency patients. Due to the potentially severe impacts of acute appendicitis, there is a tendency to over-diagnose the condition to avoid potential critical complications. However, from a health systems perspective, it is similarly vital to avoid pointless surgery for an otherwise normal appendix. In 1986, MASS presented a scoring framework in arrange to assist the clinical determination of acute appendicitis, to decrease the rate of negative appendectomies.[13,14] Its diagnostic accuracy was tested in this study in comparison to ultrasound with a sample having a mean age of 23.45 years, with similar features to other hospital-based studies.[18] Regarding age group distribution in our study, the majority of patients were 21-30 years old (51.7%) in this study, which is older than most studies in this field, which predominantly feature the age cohort aged 11-20 years.[18,19] This disparity reflects that our data were collected in Rozhalat Emergency Hospital, which only receives patients aged over 12 years.

The mean MASS score of patients in our study was 7.9 ± 1, with a maximum score of 9 and a minimum score of 7, similar to other studies.[20] Inflamed and enlarged appendix diameter was more than 6 mm, which is the most common finding of ultrasound examination (among 92.5% of appendicitis cases) in other studies.[21]

In our study, the ultrasound was found to have the following parameters: sensitivity of 82%, specificity of 65%, the diagnostic accuracy of 79.9%, positive predictive value of 94.3, and negative predictive value of 33.3. These values are similar to those reported by a similar study: sensitivity of 80%, specificity of 60%, the diagnostic accuracy of 77.5%, the positive predictive value of 93.3, and negative predictive value of 30.[20,22] This indicates that it is a reliable tool for ruling out and confirming acute appendicitis.The use of a scoring system in patients suspected of having acute appendicitis gives a wide degree of sensitivity and specificity. It has a straightforward application since it depends absolutely on clinical history, examination, and a few straightforward examinations. With the use of a scoring system, a high negative appendectomy rate was fundamentally decreased in a previous study without increasing morbidity or mortality.[23]MASS scoring based on histopathological examination in our study was positive for 82% of patients, similar to previous studies.[23,24,26] The sensitivity (95.2%), specificity (35%), and diagnostic accuracy (87%) were also the same as in previous studies,[20,26] indicating that it is a more sensitive tool for identifying acute appendicitis.

In our study, the number of patients with positive histopathology was 411 (87.9%), and the number of those with negative histopathology was 57 (12.1%), with no association with gender, affirming one previous study,[19] but differing from another study in which the positivity of histopathology was 71.3%.[26] This difference could be due to the latter having a smaller sample size, and not combining MASS score with ultrasound.

There were no significant differences between patients with positive and negative histopathology findings regarding presenting symptoms, but there was a significant association between positive histopathology findings and the cough, localized tenderness, and pointing physical signs, mimicking

a previous study. Similarly, there were no significant differences between patients with positive and negative histopathological findings regarding the physical signs of fever, rebound tenderness, Rovsing sign, psoas sign, and obturator sign. These findings affirm a previous study.[19]

The present study revealed a significant association between dysuria and frequency of symptoms with negative histopathology findings of suspected appendicitis, similar to the results of a previous inquiry.[25]

CONCLUSION

The MASS score had higher sensitivity and better ability to identify appendicitis than ultrasound, while the latter had higher specificity and a better ability to rule out appendicitis and confirm it than the MASS score, based on histopathological findings. Neither tool is superior to the other, and both need to be used together for optimum effectiveness to reduce negative appendicectomy rates.

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