Tailoring of computed tomography scanning in patients with acute appendicitis according to combined assessment by Alvarado score and focused ultrasound

Original Article

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ABSTRACT

Background: Deciding for appendectomy based only on the patient's signs and symptoms results in negative appendectomy in approimately 1/3 of cases. The rationale of this research is to decrease the negative appendectomy as well as complicated appendicitis.

Patients and Methods: This is a prospective study on 164 patients presented with acute appendicitis. We included patients of both sexes. Patients were assessed routinely using both the Alvarado score and focused ultrasound (US). Of the patients, 31 showed double positive of both Alvarado score and focused US and were considered as a control group. Computed tomography (CT) scanning was applied to 133 patients who were not double positive. Sensitivities and specificities of all tests were compared with histopathologic examination as a reference standard.

Results: CT scanning accuracy in diagnosing acute appendicitis in comparison with pathology results is 100%. Cases with +ve US and –ve Alvarado have an accuracy of 96.4% followed by cases with –ve US and +ve Alvarado, which reaches 94.3% and the least is for double-negative cases (84.4%).

Conclusion: The double-check test is a good cheap positive tool and could be used to diagnose true positive cases of acute appendicitis with a sensitivity as that of CT scanning, while CT scanning could be preserved for the negative cases by the double-check test.

Key Words: Acute appendicitis, negative appendectomy, Alvarado score, focused ultrasound, computed tomography scanning.

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INTRODUCTION

Acute appendicitis is considered one of the most frequent surgical emergencies, which could be complicated by appendiceal perforation, peritonitis, and high rate of morbidity and mortality[1]. Symptoms and signs of acute appendicitis play a role in decision-making for surgery, but this in 15%–40% of cases results in removing of normal appendices (negative appendectomy). So our aim is to decrease negative appendectomy and perforation rates[2].

Many scoring systems, imaging modalities like ultrasound (US), and new techniques have been developed to improve diagnostic accuracy and to decrease the high negative appendectomy rate. However, the majority of these modalities are complex, costly, and challenging to use in emergency situations[3].

The Alvarado score is a clinical scoring system used in the diagnosis of acute appendicitis. The score has six clinical items and two laboratory measurements with a total of 10 points. It was introduced in 1986 according to (Table 1)[4].

Imaging studies are increasing the specificity for the diagnosis of appendicitis and also reducing the negative appendectomy rate as Computed tomography (CT) scans and focused US.

US was first introduced by Puylaert in 1986[5]. Over the last 40 years, this technique has been extensively studied and improved. US should be the first imaging modality for diagnosing acute appendicitis. This will decrease ionizing radiation and cost. Nonvisualization of the appendix should lead to clinical reassessment, and complementary CT may be performed if diagnosis remains unclear.

One of the diagnostic tools in detecting acute appendicitis is CT, which has a great sensitivity and specificity in diagnosing acute appendicitis. Intravenous contrast-enhanced CT is the recommended approach for an accurate diagnosis.

The guidelines of the American College of Radiology (ACR) recommend that abdominal US should only be used in cases of pregnancy and in children under the age of 14 years[6] and CT with intravenous contrast is recommended

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for the evaluation of adults and adolescents suspected of suffering from acute appendicitis.

In our study, we aimed to determine the optimal indication for a CT scan in patients presented with acute appendicitis according to a combined assessment by Alvarado score and focused ultrasound examination.

Table 1: Alvarado score (Yegane *et al*., 2008)

Symptoms	
Abdominal pain that migrates to the right iliac fossa	**1**
Anorexia (loss of appetite) or ketones in the urine	**1**
Nausea or vomiting	**1**
Tenderness in the right iliac fossa	**2**
Signs	
Rebound tenderness	**1**
A fever of 37.3°C or more	**1**
Laboratory	
Leukocytosis >10,000	**2**
Neutrophilia>70%	**1**
TOTAL	**10**

PATIENTS AND METHODS:

Study design, setting, and approval

This is a prospective study of patients who arrived at Mansoura University Hospitals' General Surgery Department between March 2021 and March 2023 with acute appendicitis.

Eligibility criteria

We included patients with acute appendicitis of either sex aged above 18 year. Patients with chronic appendicitis, those who were admitted for elective appendicectomy after previous presentation with a mass, pregnant women, or those who did not consent to participate in the study were excluded.

Clinical examination and measurements

A detailed history was taken from the patients concerning the complaint and its duration, associated medical conditions, previous surgical operations, and previous treatments for the current condition.

Routine abdominal examination helped us to diagnose acute appendicitis from another condition.

Routine laboratory investigations including complete blood count, liver and kidney function tests, prothrombin time, and random blood glucose level were conducted. An elevated white blood cell count suggests an infectious process and is usually found in cases of acute appendicitis. A white blood cell count of more than 10,000 may suggest acute appendicitis.

The Alvarado Score was applied to all patients to determine the likelihood of having acute appendicitis. We could use the double-check test according to a previous study by Elsherbiny MW *et al*.[7],

who reported that patients were classified into one of the three groups: (1) double positive (DP) when Alvarado score greater than or equal to 7 and positive US, (2) single positive (SP) when either Alvarado score greater than or equal to 7 or positive US, or (3) double negative when Alvarado score less than or equal to 7 and negative US.

Focused US was applied to all patients to determine any positive criteria for the diagnosis of acute appendicitis. Focused US criteria[6] included:

a) When the outer diameter of the appendix measures greater than 6 mm.

b) Echogenic inflammatory peri appendicle fat change.

c) The wall thickness can measure almost 3 mm or greater.

d) Progressed appendicitis can demonstrate a gangrenous appendix. The lumen distends tremendously sometimes upwards to 2 cm and is not compressible. An appendicolith present may be present which will cast an acoustic shadow.

e) An appendicolith may be which will cast an acoustic shadow.

f) The perforated appendix is demonstrated when the appendicular wall has ruptured producing fluid or a newly formed abscess. The appearance is hyperechoic with an echo-poor abscess surrounding the appendix. There may be a reflective omentum around the appendix, a thickened bowel, and enlarged lymph nodes. Asymmetrical wall thickening may indicate perforation.

g) Free fluid in the peri-appendiceal region.

CT scanning was applied to a group of patients to determine any positive criteria for the diagnosis of acute appendicitis. CT findings included:

a) Appendix diameter is greater than 6 mm with a wall thickening of more than 2 or 3 mm.

b) Peri-appendiceal fat stranding or free fluid around the appendix.

c) Presence of an obstructing fecalith may also be present, but its absence does not preclude the diagnosis[8].

The precise diagnostic criteria have been debated; nevertheless, several recent studies contend that a cutoff of greater than 6 mm diameter is too small and can result in negative appendectomies. The average diameter of the appendix in many adult patients is between 6 and 7 mm.

For this reason, some research recommends utilizing a cutoff value of more than 7 mm to enhance CT's predictive power[9].

Patients with double-positive criteria were assumed to have definite acute appendicitis and will undergo appendicectomy without further observation or assessment, as previously described (Elsherbiny MW *et al*., 2020)[7]. Patients with single-negative or double-negative criteria in the combined assessment were further assessed with CT scanning, and according to CT results the decision was made either to proceed to surgery or to continue observation.

The sensitivity and specificity of the combined assessment by Alvarado score, focused US, and CT scanning were calculated using postoperative histopathologic examination as the reference standard.

Primary outcome measures

Evaluation of diagnostic accuracy of the combined assessment by Alvarado score and focused US in the diagnosis of acute appendicitis against CT scanning and pathology of the specimen.

Secondary outcome measures

They included the incidence of negative appendicitis (patients who are operated for appendicitis and proved to have normal appendix by the postoperative pathology), hospital stay, and postoperative complications.

Sample size calculation

Sample size calculation was based on the specificity of combined assessment by Alvarado Score and Focused US in differentiating cases with acute appendicitis retrieved from previous research[7]. Using the following link, https://wnarifin.github.io/ssc/sssnsp.html and depending on a specificity of 100.0%, prevalence of 0.64, and precision of 0.10, the total sample size will be 128 cases and by adding 20% to compensate for possible dropthe total sample size will be 164 at least.

Statistical analysis and data interpretation

Data analysis was performed by SPSS software, version 25 (SPSS Inc., PASW Statistics for Windows version 25. Chicago: SPSS Inc.). Quantitative data were described using mean± SD. The significance of the obtained results was judged at the less than or equal to 0.05 level. Mann–Whitney U and Student's t-test were used to compare between two studied groups for non-normally and normally distributed data, respectively. Two-way analysis of variance test was used to assess the combined effect of two independent factors on a dependent continuous outcome. Multiple linear regression was used to adjust for weight for comparing factors affecting change in outcome.

RESULTS:

This is a prospective case series in which 164 patients with acute appendicitis were tested for eligibility. Among those who did not double-positive (133 patients) who ultimately had a CT scan to confirm or rule out the diagnosis of acute appendicitis, seven patients showed clinical improvement with conservative measures and were successfully discharged from the hospital.

The mean age of the studied cases is 33.02±13.82 years with an interquartile range from 23 to 39 years. Among studied cases, 57.3% were males, and 42.7% are females. (Table 2).

Symptoms and signs were assessed using the Alvarado score. The most common symptom was tenderness in the right iliac fossa (73.2%) and fever greater than or equal to 37.3 °C, while the least common symptoms were nausea or vomiting where both presented in 53.3% of the entire cohort. More detailed data regarding the Alvarado score are shown in (Table 3).

The diagnosis was initially investigated using a focused US. With the presence of one or more signs of acute appendicitis, the test is deemed positive. The most common signs were peri-appendicular free fluid (31.8%) and peri-appendicular fat changes (30.6%). More detailed data regarding the focused US assessment are shown in (Table 4).

Decision-Making and operative details

After the application of the double-check test method in the confirmation of the diagnosis, only 18.9% of the patients showed a double-positive result, about 28% single –ve US and +ve Alvarado, 27.4% single +ve US and –ve Alvarado, and about 25.6% showed a double-negative result (Table 5).

The decision to take the patient to the operating theater was influenced not only by the use of a double-check test but also by the results of the CT scan if available, the disproportion between clinical and radiological assessment, deterioration of symptoms and signs after conservation, and the opinion and/or the experience of the attending surgeon and the surgeon on call.

Histopathologic examination showed positive results in approimately 97% of the operated patients. More details regarding decision-making and operative findings are shown in (Table 6 and Table 7).

CT scanning accuracy in diagnosing acute appendicitis in comparison with pathology results is 100%, which is also reached by double-positive cases (positive by the US and positive by the Alvarado score).

Cases with +ve US and –ve Alvarado have an accuracy of 96.4% followed by cases with –ve US and +ve Alvarado which reaches 94.3% and the least is for double-negative cases (84.4%) (Table 8).

Table 2: Demographic characteristics of the studied cases

Basic Data	N=164 (%)
Age/years	
Mean ±SD (interquartile range)	33.02±13.82 (23–39)
Sex	
Male	94 (57.3)
Female	70 (42.7)

Table 3: Detailed Alvarado score

Alvarado score domains	N=164 (%)
Migration	95 (60.5)
Anorexia or ketones	87 (55.4)
Nausea or vomiting	84 (53.3)
Tenderness in the right iliac fossa	115 (73.2)
Rebound tenderness	100 (63.7)
Fever ≥ 37.3 °C	111 (70.7)
Leukocytosis >10,000	97 (61.8)
Neutrophilia >70%	100 (63.7)
Total	6.26±1.6 6(2–9)

Table 4: Detailed focused ultrasound findings

Focused Ultrasound	N=164 (%)
Diameter > 6 mm	49 (31.2)
Peri-appendicular fat changes	48 (30.6)
Thickness ≥ 3 mm	46 (29.3)
Appendicolith	42 (26.8)
Abscess	2 (1.3)
Peri-appendicular free fluid	50 (31.8)

Table 5: Distribution of the studied cases according to results of ultrasound and Alvarado score

Diagnosis	n (%)
Double positive	31 (18.9)
Single +ve US and –ve Alvarado	45 (27.4)
Single -ve US and +ve Alvarado	46 (28.0)
Double negative	42 (25.6

Table 6: Decision-making and operative details

Surgery decision	N=157 (%)
Open	136 (86.6)
Lap	21 (13.4)
Operative findings	
Anesthesia	
Spinal	129 (82.2)
General	28 (17.8)
Incision	
Midline	5 (3.2)
Lap	22 (14.0)
Grid-iron	130 (82.8)
Appendix state	
Negative	5 (3.2)
Inflamed	149 (94.9)
Perforated/gangrenous	3 (1.9)

Table 7: CT scan findings among the studied cases

CT scanning	N=133 (%)
Negative	12 (9.0)
Positive	121 (91.0)

Table 8: Diagnostic accuracy of the combined assessment by Alvarado score and focused ultrasound in the diagnosis of acute appendicitis against computed tomography scanning and pathology of specimen

	Sensitivity%	Specificity%	PPV%	NPV%	Accuracy%
Double positive	100.0	100.0	100.0	100.0	100.0
Single +vet US and –vet Alvarado	100.0	83.3	95.6	100.0	96.4
Single –ve US and +ve Alvarado	100.0	70.0	93.5	100.0	94.3
Double negative	100.0	30.0	83.3	100.0	84.4
CT scan	100.0	100.0	100.0	100.0	100.0

DISCUSSION

Acute appendicitis is the most frequent surgical condition in industrialized countries. After nonspecific abdominal pain and constipation, it is the second cause of right lower quadrant pain in patients coming to the emergency department[10].

Major retrospective trials showed that CT scanning and abdominal US have a similar specificity for diagnosing acute appendicitis, and repeated CT scans may increase the risk of brain cancer and leukemia in younger populations[11].

Negative appendectomies, complications of surgery, and total healthcare expenses have all decreased dramatically since pre-surgical imaging was introduced[12].

Numerous scores are available for cases of suspected acute appendicitis, such as the RIPASA score for Asian persons, the Adult Appendicitis Score, the Pediatric Appendicitis Score, and the Appendicitis Inflammatory Response Score. The modified Alvarado Score, which consists of seven characteristics, is the most often used to clinically evaluate acute appendicitis[13].

Therefore, the current study aimed to determine the optimal indication for a CT scan in patients presented with acute appendicitis according to a combined assessment by Alvarado score and focused US examination. The current study included 164 patients with acute appendicitis of either sex aged above 18 year.

The current study showed that the mean age of the studied cases was 33.02±13.82 years. Among the studied cases 57.3% were males and 42.7% were females. The median hospital stay of the studied cases was 2 days ranging from 1 to 10 days.

The current study evaluated Alvarado score among studied cases including migration (95%), Anorexia or ketones (among 55.4% of cases), nausea or vomiting (among 53.3%), tenderness in the right iliac fossa (among 73.2%), rebound tenderness (among 63.7%), fever greater than or equal to 37.3 °C (among 70.7%), leukocytosis greater than 10 000 (among 61.8%), and neutrophilia greater than 70% (among 63.7%). The mean total Alvarado score is 6.26±1.6 with a median of 6 ranging from 2 to 9.

Consistent with our results, the 2020 research by Elsherbiny *et al*.[7] had 200 patients with a mean age of 32±7±18 years, 51±5% of whom were male. The median Alvarado score was 7 (range, 1–10)

As regards focused US, the current study illustrated that 31.2% of the studied cases had a diameter greater than 6 mm, 30.6% peri-appendicular fat changes, 29.3% thickness greater than or equal to 3 mm, 26.8% appendicolith, 1.3% abscess, and 31.8% peri-appendicular free fluid[14].

The Abd ElFatah *et al*.[15] study included 45 patients who were presented with symptoms of acute appendicitis, examined by pelvi-abdominal US and then contract-enhanced CT. Positive US findings included: distended appendix in 44.4%, peri-appendiceal fluid collection in 71.1%, echogenic fat in 53.3%, and suspected complications (such as perforation or abscess formation) in 11.1%.

Regarding treatment among studied cases, the current study found that seven cases underwent conservative treatment and 157 underwent surgical intervention; 86.6% of the studied cases allocated for open surgery and 13.4% allocated for lap. The appendix state was distributed as follows: 94.9% inflamed, 3.2% negative, and 1.9% perforated or gangrenous. All cases need to drain.

Of the 798 patients in the Crocker *et al*.[16] study group, 346 (43.4%) underwent appendectomy. Twenty specimens were negative for appendicitis, resulting in an overall NAR of 5.8%.

Interestingly, the current study illustrated that the studied cases were classified according to the results of US and Alvarado score as follows: 28% single (–ve US and +ve Alvarado), 27.4% single (+ve US and –ve Alvarado), 25.6% double negative, and 18.9% double positive.

However, Elsherbiny *et al*.[7] found that combined US and Alvarado scores identified individuals who were either double positive or double negative. Double-positive patients had a percentage of 46±5% with positive US results and an Alvarado score greater than or equal to 7; double-negative patients had a percentage of 30% with normal or inconclusive US findings and an Alvarado score less than 7.

Moreover, the CT scan was done, in the current study, for 133 cases that were not double positive and revealed that 91% of cases were positive and 9% were negative.

In agreement, Jones *et al*.[14] showed that among the 70 patients with Alvarado scores of 4 or higher, 12 patients had appendicitis, all proved by pathologic examination. These 12 patients included 11 true-positive diagnoses and one false-negative diagnosis by CT.

Specifically, the current study demonstrated that CT scan accuracy in diagnosing acute appendicitis in comparison with pathology results was 100%, which was also reached by double-positive cases (positive by the US and positive by the Alvarado score). For cases with +ve US and –ve Alvarado, the accuracy was 96.4% followed by cases with –ve US and +ve Alvarado which reached 94.3% and the least was for double-negative cases (84.4%).

According to Mannil *et al*.[5], the modified Alvarado score alone has a sensitivity of 90% and a specificity of 84.4%; in contrast, the new clinical–radiological score demonstrates an enhanced sensitivity of 91.4% (87%–100%) and a markedly increased specificity of 100% (77%–100%).

According to Elsherbiny *et al*.[7], the combined US and Alvarado score had 68±4%, 100%, and 71±9% sensitivity, specificity, and accuracy in detecting acute appendicitis.

However, other research demonstrated that the combined evaluation methods have diagnostic accuracy more than the Alvarado score alone. The combined evaluation approach showed better specificity but poorer sensitivity and accuracy when compared with CT scanning[17,18].

Combined US and Alvarado score were specific in the diagnosis of acute appendicitis identifying all patients with a normal appendix. This can be useful in limiting of the use of CT scanning to patients with a single- or double-negative criterion (Sirpaili *et al*.)[19].

The current study showed that the incidence of negative appendicitis (patients who are operated for appendicitis and proved to have normal appendix by the postoperative pathology) was among 5 cases out of 157 operated cases (3.2%).

Elsherbiny *et al*.[7] found the negative appendectomy rate to be 7% in men and 17% in women, lower than what Matthews *et al*. [20] reported in the RIFT study (12% and 28%, respectively).

The current study illustrated no statistically significant difference as regards the length of hospital stay between cases diagnosed with negative versus positive appendicitis (1.80±0.45 vs 2.82±1.80 days, respectively). None of the studied cases showed complications as regards bleeding, leakage, fistula, and SSI.

Moreover, the current study found no statistically significant difference between cases with negative versus positive pathology (acute appendicitis) as regards Alvarado score (1.80±0.45 vs. 2.83±1.80, respectively, for negative and positive cases) and as regards focused ultrasound findings including diameter greater than 6 mm, peri-appendicular fat changes, thickness greater than or equal to 3 mm, appendicolith, abscess, and peri-appendicular free fluid (*P>0.05*).

The heterogeneity of the above-mentioned results could be attributed to many reasons, the difference in population, patient geographic distribution, experience in the US, and the medical centers.

CONCLUSION

The double-check test is a good cheap positive tool and could be used to diagnose true positive cases of acute appendicitis with a sensitivity as that of CT scanning, while CT scanning could be preserved for the negative cases by the double-check test.

CONFLICT OF INTEREST

There are no conflicts of interest.

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