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Original Article

Surgery Section

Clinical Study for Efficacy of Different Diagnostic Tools for the Diagnosis of Acute Appendicitis

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ABSTRACT

Introduction: Acute Appendicitis (AA) is one of the most common causes of surgical abdominal pain and can be confused with other diseases due to atypical presentations of the disease. So, to aid in the diagnosis the various scoring systems and radiochemical investigations are in use such as Modified Alvarado Score (MAS), Ultrasonography (USG) of abdomen, Computed Tomography (CT) scan of abdomen and serum bilirubin levels.

Aim: To study the diagnostic efficacy of MAS, USG of abdomen, CT scan of abdomen and serum bilirubin level for the diagnosis of AA.

Materials and Methods: This was a prospective observational study conducted in the North Eastern Indira Gandhi Regional Institute of Health and Medical Sciences, Shillong, Meghalaya, India. A total of 72 patients with the clinical diagnosis of AA participated in the study. The patients were subjected to MAS, USG of abdomen; serum bilirubin level and Contrast-Enhanced Computed Tomography (CECT) scan on admission. Sensitivity, specificity, positive predictive value and negative predictive value for each test were found. Final diagnosis was confirmed histopathologically. Descriptive statistics data were calculated using SPSS version 22.0.

Results: Sensitivity was highest for USG 42 (80.77%) out of 52. Specificity was highest for CT scan 18 (90%) out of 20, when target sign was found positive in the patient and also in cases of serum bilirubin 18 (90%) out of 20 when the patient had perforated appendicitis. Otherwise the overall diagnostic accuracy of USG was the highest 47 (65.28%) of 72.

Conclusion: Diagnosis of AA is still challenging as the overall sensitivity or specificity of scoring system as well as radiochemical analysis is still very poor.

Keywords: Modified alvarado score, Serum bilirubin, Ultrasonography of abdomen

INTRODUCTION

The AA is one of the most common causes of surgical abdominal pain [1]. If not diagnosed correctly, unnecessary appendectomy or complications due to appendicular perforation may increase morbidity. Therefore, timely diagnosis of AA is imperative. Although, AA can often be diagnosed by a simple examination and laboratory tests, but confirming the diagnosis can be difficult if the signs and symptoms are atypical. Data from previous studies report, the negative appendectomy rate as 16.5-22.8%, and perforated appendectomy rate as 15-23% [2].

Alvarado scoring system is a practical evaluation method used to diagnose AA by scoring patient's complaints and symptoms. It was first proposed by Alvarado A [3]. The AA can be correctly diagnosed in 70% of patients by using alvarado scoring alone [4]. Taking into consideration that counting the White Blood Cell (WBC) differentials is not routine in many laboratories, the MAS was developed by omitting the left shift of leukocytosis from the alvarado scale [5]. The USG is an inexpensive, fast and noninvasive method with a relatively high accuracy rate for the diagnosis of AA [6]. Due to the high sensitivity, specificity, and accuracy rates CT scan is being used increasingly in the diagnosis of AA [7]. Bilirubin is a marker of perforation in appendicitis, but is not accurate enough to be diagnostic [8].

This study was undertaken to evaluate the diagnostic accuracy of the various diagnostic modalities in the subset of patients belonging to the North Eastern part of the country.

MATERIALS AND METHODS

This was a prospective observational study conducted in the North Eastern Indira Gandhi Regional Institute of Health and Medical Sciences, Shillong, Meghalaya, India. A total of 72 patients were studied over a period of one and half years duration from November 2014 to May 2016. Ethical approval was obtained from the Institute Ethics Committee. Informed consent was obtained from each patient. All patients underwent open appendicectomy.

Inclusion Criteria

Every patient with acute Right Iliac Fossa (RIF) pain was subjected to MAS, USG abdomen, serum bilirubin level and CT scan at admission. USG was done by the same operator and CT reporting was also done by the same radiologist. A diagnosis of appendicitis was concurred in the following situation:

Parameters	Findings for Acute Appendicitis
MAS	Score >7
USG abdomen	Appendicular diameter >6 mm, periappendiceal collection, feacolith and target sign. Presence of any one or all signs favours AA.
CECT	Appendicular diameter >6 mm, periappendiceal collection and target sign. Presence of any one or all signs favours AA.
Serum bilirubin	>2 mg

Other clinical, radiological and haematological examinations required to diagnose and manage the patient were also done.

The MAS is calculated from three symptoms, three signs and one laboratory parameter as follows: migratory RIF pain-1 point, nausea/vomiting-1 point, anorexia-1 point, tenderness in RIF-2 points, rebound tenderness in RIF-1 point, elevated temperature-1 point and leucocytosis-2 points. The total score for MAS is 9. A score of 7 is taken as definitive of AA, a score of 5-6 is equivocal and a score <5 is usually not appendicitis.

Exclusion Criteria

The following patients were excluded from the study: unwilling patients, pregnant women, patients presenting with RIF lump, patients with known liver disease or ingestion of hepatotoxic drugs within last one month.

STATISTICAL ANALYSIS

Data was collected and entered in Microsoft Excel software. Descriptive statistics were calculated using SPSS version 22.0 and specificity, sensitivity and positive predictive value and negative predictive value were calculated using 2×2 table (MedCalc) statistical software.

RESULTS

A total of 72 patients were included in the study, of which 32 (44%) were males and 40 (56%) were female patients. A total of 52 patients truly had AA proven histopathologically. The minimum age for the patients included in the study was four years and maximum age was 56 years with a range of 52 years. The mean age of the population under study was 28.14±13.34 years with variance of 178.12. The median age was 27 years and mode was 28 years. The most common age group in present study was 21-30 years followed by 11-20 years. The age distributions of the entire study population are shown in [Table/Fig-1].

Age Group (years)	Number of Patients (%)
0-10	4 (5.6)
11-20	18 (25)
21-30	24 (33.3)
31-40	11 (15.2)
41-50	8 (11.1)
51-60	7 (9.7)

[Table/Fig-1]: Showing age distributions for the population under study.

Pain in the RIF was the most common clinical presentation 65 (90.2%) out of 72, followed by anorexia 58 (80.5%) out of 72, nausea and vomiting 44 (61.1%) out of 72. The various clinical presentations are shown in [Table/Fig-2].

Clinical presentation	Number of patients (%)
Pain in right iliac fossa	65 (90.2)
Anorexia	58 (80.5)
Nausea and vomiting	44 (61.1)
Fever	30 (41.7)
Migratory pain	14 (19.4)
Rebound tenderness	11 (15.3)

[Table/Fig-2]: Showing clinical presentations of patients with acute appendicitis.

Maximum number of patients with AA had MAS of more than 7 (59.62%) followed by MAS of ≤5 (21.15%) and MAS of 5-6 (19.23%). The results of the MAS of patients with AA are shown in [Table/Fig-3].

Modified Alvarado Score	Number of Patients (%)	Appendicitis by Histopathology (%)
≤5	19 (26.4)	11 (21.15)
5-6	14 (19.4)	10 (19.23)
≥7	39 (54.2)	31 (59.62)
Total	72 (100)	52 (100)

[Table/Fig-3]: Showing modified alvarado score of patients with acute appendicitis.

On USG assessment, majority of the patients with diagnosed AA had appendicular diameter >6 mm 42 (80.8%) out of 52 and presence of periappendiceal collection 34 (65.4%) out of 52, but few patients had presence of feacolith 19 (36.5%) out of 52 and target sign 14 (26.9%) out of 52. An overall summary of USG findings in patients with AA is shown in [Table/Fig-4].

Ultrasonographic parameter	Present (%)	Appendicitis (%)
Appendicular diameter ≥6 mm	57 (79.2)	42 (80.8)
Periappendiceal collection	48 (66.7)	34 (65.4)
Appendicolith	27 (37.5)	19 (36.5)
Target sign	18 (25)	14 (26.9)

[Table/Fig-4]: Various ultrasonographic findings in patients with acute appendicitis confirmed histopathologically.

Serum total bilirubin levels were divided into those having between <1 mg/dL, 1-2 mg/dL and ≥2 mg/dL. Maximum number of patents 58 (80.6%) out of 72 had a serum bilirubin level <1 mg/dL [Table/Fig-5].

Serum total bilirubin (mg/dL)	Number of patients (%)	Appendicitis (%)
<1	58 (80.6)	42 (80.77)
1-2	9 (12.5)	7 (13.46)
>2	5 (6.9)	3 (5.77)
Total	72 (100)	52 (100)

[Table/Fig-5]: Showing total serum bilirubin levels in patients with acute appendicitis.

On CECT assessment, majority of the patients had appendicular diameter >6 mm 39 (75.00%) and presence of periappendicular collection 37 (71.15%) out of 52, few patients had target sign positive 21 (40.38%) out of 52. The [Table/Fig-6] shows the CECT findings in patients with AA.

CECT parameters	Number of patients (%)	With appendicitis (%)
Diameter ≥6 mm	55 (76.4)	39 (75.00)
Periappendiceal collection	48 (66.7)	37 (71.15)
Target sign	23 (31.9)	21 (40.38)

[Table/Fig-6]: Showing CT based diameters of appendix in patients with acute appendicitis.
CECT: Contrast enhanced computed tomography

After statistical measure of performance of MAS, USG of abdomen, CECT abdomen and serum bilirubin levels in patients with acute appendicitis, sensitivity was highest in USG 42 (80.77%) out of 52 patients, followed by CECT 39 (75.00%) out of 52, MAS 31 (59.62%) out of 52 and bilirubin 3 (5.77%) out of 52 patients.

Majority of patients had serum bilirubin level <1 mg/dL 42 (80.77%) out of 52 patients with AA, but specificity was highest with serum bilirubin 18 (90.00%) out of 20 patients, when the serum bilirubin level was >2 mg/dL. CECT also had a specificity of 18 (90.00%) out of 20 patients with positive target sign, followed by USG of abdomen 16 (80.00%) out of 20 patients with positive target sign and MAS 31 (79.4%) out of 39 patients with MAS >7 actually had AA.

Positive predictive value was highest with CECT 21 (91.30%) out of 23 patients with positive target sign, followed by MAS 31 (79.49%) out of 39 patients with MAS >7, USG of abdomen 14 (77.78%) out of 18 patients with positive target sign and serum bilirubin 3 (60.00%) out of 5 patients with serum bilirubin >2 mg.

Negative predictive value was highest with CECT 9 (37.50%) out of 24 patients with periappendiceal collection, followed by MAS 12 (36.36%) out of 33 patients with score ≥7, USG 5 (33.33%) out of 15 patients with appendicular diameter ≥6 and serum bilirubin 18 (26.87%) out of 67 patients. The [Table/Fig-7,8] shows the statistical measures of performance and showing the overall diagnostic efficacy of the various diagnostic modalities in diagnosing AA.

Diagnostic modality	Parameters	Sensitivity (95% CI)	Specificity (95% CI)	Positive predictive value (95% CI)	Negative predictive value (95% CI)
MAS		59.62% (45.10-72.99)	60.00% (36.05-80.88)	79.49% (68.42-87.39)	36.36% (25.99-48.18)
USG	Appendicular diameter	80.77% (67.47-90.37)	25.00% (8.66-49.10)	73.68% (67.7-78.84)	33.33% (16.32-56.18)
	Periappendiceal collection	65.38% (50.91-78.03)	30.00% (11.89-54.28)	70.83% (63.15-77.48)	25.00% (13.41-41.78)
	Faecolith	36.54% (23.62-51.04)	60.00% (36.05-80.88)	70.37% (55.47-81.91)	26.67% (19.39-35.47)
	Target sign	26.92% (15.57-41.02)	80.00% (56.34-94.27)	77.78% (56.67-90.35)	29.63% (24.25-35.65)
CT	Appendicular diameter	75.00% (61.05-85.97)	20.00% (5.73-43.66)	70.91% (65.05-76.14)	23.53% (10.21-45.42)
	Periappendiceal collection	71.15% (56.92-82.87)	45.00% (23.06-68.47)	77.08% (68.58-83.83)	37.50% (23.93-53.37)
	Target sign	40.38% (27.01-54.90)	90.00% (68.30-98.77)	91.30% (73.02-97.60)	36.73% (30.77-43.13)
Serum bilirubin		5.77% (1.21-15.95)	90.00% (68.30-98.77)	60.00% (21.29-89.27)	26.87% (23.83-30.14)

[Table/Fig-7]: Showing statistical measure of performance of MAS, USG, CECT and serum bilirubin in acute appendicitis.
MAS: Modified alvarado score, USG: Ultrasonography, CT: Computed tomography

Diagnostic Modality	Diagnostic Accuracy	95% Confidence Interval
MAS	59.72%	47.50-71.12%
USG	65.28%	53.14-76.12%
CT	59.72%	47.50-71.12%
Bilirubin	29.17%	19.05-41.07%

[Table/Fig-8]: Showing the overall diagnostic accuracy of the various diagnostic modalities.
MAS: Modified alvarado score, USG: Ultrasonography, CT: Computed tomography

DISCUSSION

In the present study sensitivity was found to be highest with USG (80.77%) along with specificity of (80%) when appendicular diameter and target signs are taken into consideration. The specificity was seen highest with CT scan and also with serum bilirubin estimation when AA was associated with appendicular perforation. The overall diagnostic accuracy was seen to be highest with USG (65.28%) followed by MAS (59.72%) and CT scan (59.72%) and serum bilirubin estimation had the lowest diagnostic yield.

Terasawa T et al., in their systemic reviews has found the sensitivity of USG in AA as 81-88% and specificity as 78-84% similar to the present study [8]. However, USG is an operator-dependent modality, and the diagnostic values are different in various studies [6].

The sensitivity and the accuracy rates of CT imaging with contrast vary between 96-98% and 93-98%, respectively and without contrast vary between 87-90% and 93-97%, respectively [9]. The sensitivity in the present study was 75% with a diagnostic accuracy of 59.72% only. However, being expensive, the time taken for its preparation and imaging, the need to use contrast, and the exposure to ionizing radiation in children and adolescents constitute the limitations for its use as the first choice [7]. Overall, USG performs inferior in terms of diagnostic accuracy than CT. In two meta-analysis the sensitivity and specificity were 0.78-0.86 and 0.81-0.83, respectively [6,10]. However, in experienced hands, and for both paediatric and adult patients, diagnostic accuracy well over (90%) is reported [11]. The diagnostic yield of USG for diagnosing AA in the present study was 65.28% only.

In the present study, CT scan has been taken as one of the diagnostic modalities for AA keeping in mind the radiation exposure risk to the patients; as CT scan is chosen more frequently than USG as preoperative workup in patients with AA; due to better sensitivity, specificity, accuracy, non-dependency on the operator and ability to rule out other surgical causes of acute abdomen [12-15].

Certain amount of research has been undertaken to identify specific cases of perforated appendicitis depending on clinical examination with supportive evidence of raised inflammatory and biochemical markers. Hyperbilirubinemia is one such biochemical marker which has generated considerable interest in the supportive diagnosis of perforated appendicitis [16]. A previous study reported a sensitivity (62.96%) and specificity (88.31%) when using raised levels of bilirubin as a marker for perforated appendix [8]. The sensitivity in the present study for hyperbilirubinemia was found to be only (5.77%) but the specificity was (90%) in patients with perforated appendicitis. In a patient with high clinical suspicion of AA, a raised bilirubin suggests that a patient is not suitable for conservative treatment [6].

A large number of scoring systems have been proposed. Some are exclusively designed for children, others for adults and some for patients of all ages. The Alvarado score, MAS, the Lintula score, and the Paediatric Appendicitis Score (PAS) are among the most well-known and widely used [17]. Alvarado score is noninvasive diagnostic method which is simple, reusable and repeatable and can establish the diagnosis of AA [18,19]. In the present study, it has been seen that MAS had similar diagnostic accuracy to CT scan (59.72%) without added disadvantages of radiation exposure, which is the hallmark finding in the present study.

LIMITATION

Very few patients with AA actually had clinically significant serum bilirubin (>2 mg/dL) which has given a very high specificity for this particular diagnostic modality.

CONCLUSION

To conclude, USG is an effective diagnostic tool. MAS is a simple diagnostic modality having diagnostic accuracy similar to CT scan and can complement USG without the need to get radiation exposures. Hyperbilirubinemia as a marker can be useful in patients with perforated AA.

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