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Beneficial Role of Combined Use of Modified Alvarado Scoring System and Ultrasonography in Diagnosis of Acute Appendicitis

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ABSTRACT
Introduction*: Acute appendicitis is the most common surgically correctable cause of abdominal pain. The diagnosis of acute appendicitis is mainly clinical; however, a decision to operate based on clinical suspicion alone can lead to removal of a normal appendix in 15-30% cases. A delay in the diagnosis and management can lead to complications such as appendicular rupture, abscess and peritonitis.*
Materials and Methods*: During the period of study from 1st June 2021 to 31st May 2022, 102 patients with presumptive diagnosis of acute appendicitis admitted in Department of Surgery, GMCH were taken up for the purpose of the study. Appropriate haematological and radiological investigations were done as required. Final diagnosis of acute appendicitis has been confirmed on basis of histopathological reports and absence of any complications (abscess, perforation etc) in intraoperative findings.*
Results and Observations*: Our study population comprised 102 patients with presumptive diagnosis of acute appendicitis out of which 54 patients were Male (53%) and 48 patients were Female (47%). Majority of the patients (50.9%) were observed to be in the Age group of 21-30years. Combination of Alvarado score and Ultrasonography with at least one positive has proven to be effective in the diagnosis of acute appendicitis as it has a higher sensitivity& higher negative predictive value. When USG and Alvarado score are combined with both positive, the specificity is increased and negative appendicectomy rate is reduced. When Alvarado score alone is considered, diagnostic accuracy is high and negative appendicectomy rates are least.*
Conclusion*: A combination of Alvarado score and Ultrasonography is a better diagnostic tool in diagnosing acute appendicitis when compared to either Alvarado score or Ultrasonography separately. The combination can decrease the need for unnecessary radiological investigations and also decrease the rate of negative appendicectomies.*
Key words:*Acute appendicitis, Alvarado scoring, Ultrasonography*

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I. INTRODUCTION

Acute appendicitis is perhaps the most common surgically correctable cause of abdominal pain, approximately 6% of the population will suffer from this disease during their lifetime [1]. It is rare in infancy and amongst the elderly, but is common in children, teenagers andyoung adults [2]. Appendicectomy is the treatment of choice.

The diagnosis of acute appendicitis is essentially clinical; however, a decision to operate based on clinical suspicion alone can lead to removal of a normal appendix in 15-30% cases. A delay in the diagnosis and management can lead to complications such as appendicular rupture,abscess and peritonitis.

Various clinical, biochemical and radiological methods such as Alvarado scoring system, C-reactive protein (CRP) values, Total leucocyte count (TLC), Ultrasonography (USG), Computed Tomography (CT) and Magnetic Resonance Imaging (MRI) are used in the diagnosis of acute appendicitis. Attempts to increase the diagnostic accuracy of acute appendicitis have included even laparoscopy and radioactive isotope imaging [3,4,5,6].

Diagnostic efficacy of Alvarado score and Ultrasonography can be increased by using them in combination with each other, or with other investigations such as CRP.

II. AIMS AND OBJECTIVES

1) To compare and evaluate diagnostic accuracy of Ultrasonography and Modified Alvarado Scoring System and their combination with histopathology report in patient with acute appendicitis.
2) To study sensitivity, specificity of Modified Alvarado Scoring System and Ultrasonography in patient with acute appendicitis.
3) To study Positive and Negative predictive values and percentage of true positives and false negatives using Modified Alvarado Scoring System and Ultrasonography separately and by combining them in patient with acute appendicitis.

III. MATERIALS AND METHODS

It is a prospective comparative study conducted in Gauhati Medical College and Hospital in the period of 1 year from 1st June 2021 to 31st May 2022, wherein, 102 patients with presumptive diagnosis of acute appendicitis admitted in Department of Surgery were taken up for the purpose of study.

Patient Selection: Patients selected for this study arethose diagnosed withpresumptive diagnosis of acute appendicitis

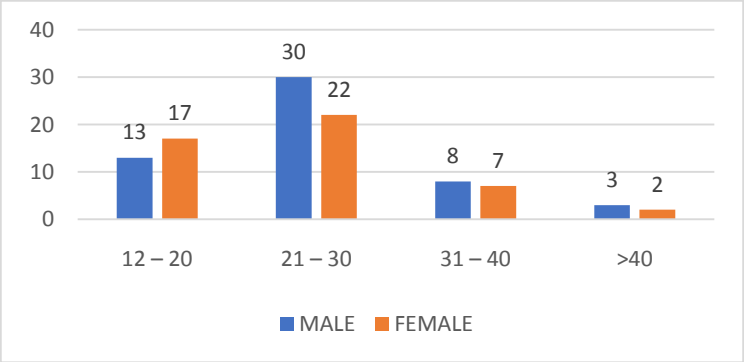
Inclusion Criteria: Age more than 12 years, Acute abdominal pain clinically presumed to be of appendicular origin.

Exclusion Criteria: Age less than 12 years, Palpable mass on abdominal examination, Signs of generalized peritonitis, Patient who are not willing for appendicectomy

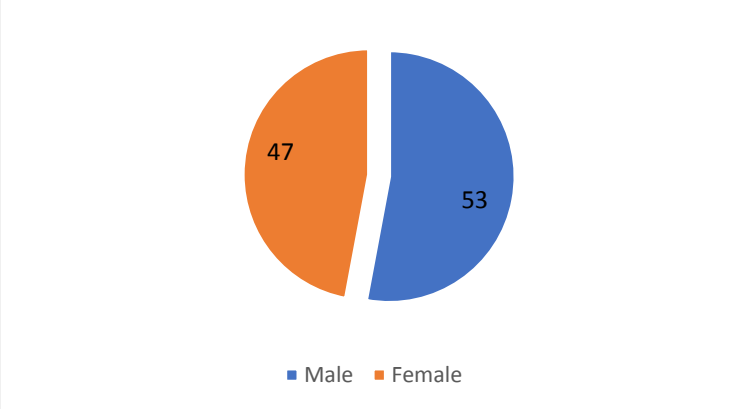
Appropriate haematological and radiological investigations were done as required. Final diagnosis of acute appendicitis has been confirmed on basis of histopathological reports and absence of any complications (abscess, perforation etc) in intraoperative findings.

IV. RESULTS AND OBSERVATION

Graph showing distribution Of Age and Sex in Modified Alvarado Scoring

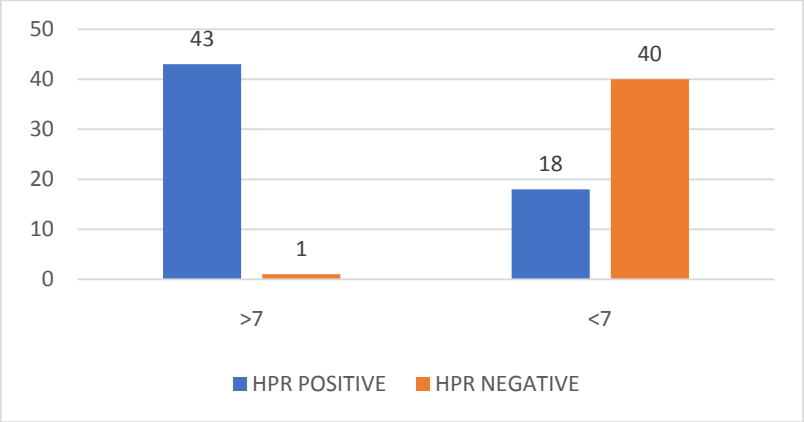


Graph Showing Distribution of Male and Female Ratio In Modified Alvarado Scoring



In our study, the total number of male patients was 54 (53%) and number of female patients was 48 (47%) and M: F Ratio is 1.125:1

Graph showing Histopathology Diagnosis Distribution with Modified Alvarado Scoring



In our study for Modified Alvaradoscore ≥7, total patients were 44out of which histopathology reporting positive in 43 and 1 histopathology reportingnegative. In Modified Alvaradoscore<7, total patients were 58 in which 18 were histopathology reporting positive and 40 were histopathology reporting negative.

Gender distribution of results of histopathology for all patients

GENDER	POSITIVE HPR	PERCENTAGE	NEGATIVE HPR	PERCENTAGE
FEMALE N =48	30	49.1%	18	43.9%
MALE N =54	31	50.9%	23	56.1%
TOTAL N =102	61	100%	41	100%

In our study, 61 patients confirmed appendicitis by histopathology in which 30 patients (49.1%) were female and 31 (50.9%) were male. Onthe other hand, in 41 patients in whom appendicitis was not confirmed, 18(43.9%) were female and 23(56.1%) were male.

Result of Our Treatment Plan (≥7)

SEX	**MAS ≥7**	**USG +ve**	**Confirmed appendicitis**
Male	21	19 (90.4%)	18 (85.7%)
Female	23	23 (100%)	23 (100%)
	44	42	41

In our study, number of males in the Modified Alvarado score range of ≥7 were 21 patients in which, number of Ultrasonography +vewere 19(90.4%) and number of confirmed appendicitis were 18 (85.7%)

Number of females in the Modified Alvarado score range ≥7 was 23 patients in which ultrasonography +vewas 23(100%) and number of confirmed appendicitis was also 23(100%)

Result of Our Treatment Plan (<7)

SEX	**MAS <7**	**USG +ve**	**Confirmed appendicitis**
Male	33	18 (54.4%)	6 (18.2%)
Female	25	9 (36%)	5 (20%)
	58	27	11

In our study, number of males in the Modified Alvarado score range of <7 was 33 patients, inwhich number of ultrasonography +vewas 18(54.4%) and number of confirmed appendicitis was 6 (18.2%)

Number of females in the Modified Alvarado score range <7 was 25 patients in which Ultrasonography +vewas 9(36%) and number of confirmed appendicitis was 5(20%).

Overall Sensitivity and Specificity of our diagnostic approach

Diagnostic approach result	Diagnosis		Total
	Appendicitis	Non appendicitis	
Positive	True +ve (52)	False +ve (19)	71
Negative	False –ve (9)	True –ve (22)	31
Total	61	41	102

In our study, in the diagnosis of appendicitis, true +ve cases are 52 and false –ve case are 9 and in non-appendicitis, false +ve cases are 19 and true –ve cases are 22

By our diagnostic approach, Sensitivity =85.25%, Specificity=53.66%, Positive predictive=73.24%, Negative predictive=70.97%, Accuracy=72.55%, Negative appendectomy rate is 26.7%.

Sensitivity and Specificity of Ultrasonography

Diagnostic approach result	Diagnosis		Total
	Appendicitis	Non appendicitis	
Positive	True +ve (52)	False +ve (17)	69
Negative	False –ve (9)	True –ve (24)	33
Total	61	41	102

In our study, in the diagnosis of appendicitis, true +ve cases are 52 and false –ve cases are 9 and in non-appendicitis, false +ve cases are 17 and true –ve cases are 24.

In our study for ultrasonography, Sensitivity =85.25 %, Specificity =58.54%, Positive predictive=75.36%, Negative predictive = 72.73%, Accuracy=74.51%, Negative appendicectomy rate (false positive) =24.6% and Negative appendicectomy rate (false negative) =27.27%.

Sensitivity and Specificity of Modified Alvarado score

Diagnostic approach result	Diagnosis		Total
	Appendicitis	Non appendicitis	
Score ≥7	43	1	44
Score <7	18	40	58
Total	61	41	102

In our study, in the diagnosis of appendicitis, true +ve cases are 43 and false –ve cases are 18 and in non-appendicitis, false +ve cases are 1 and true –Ve cases are 40

In our study for Alvarado score ≥7, Sensitivity =70.49 %, Specificity=97.56%, Positive predictive=97.73%, Negative predictive=68.97%, Accuracy=81.37%. Negative appendicectomy rate (false positive rate) = 2.27%.

Sensitivity and Specificity in combination of Modified Alvarado and Ultrasound (at-least one positive)

Diagnostic approach result	Diagnosis		Total
	Appendicitis	Non appendicitis	
Positive	54	17	71
Negative	7	24	31
Total	61	41	102

In our study, in the diagnosis of appendicitis with the combination of Alvarado and ultrasound (atleast one positive) true +ve cases are 54 and false –ve cases are 7 and in non-appendicitis, false +ve cases are 17 and true –Ve cases are 24

In our study with the combination of Alvarado and ultrasound (at least one positive) Sensitivity =88.52 %, Specificity=58.54%, Positive predictive= 76.06 %, Negative predictive=77.42%, Accuracy=76.47%. Negative appendicectomy rate (false positive rate) = 23.94%.

Sensitivity and Specificity in combination of Alvarado and ultrasound (both positive)

Diagnostic approach result	Diagnosis		Total
	Appendicitis	Non appendicitis	
Positive	True +ve (41)	False +ve (1)	42
Negative	False –ve (20)	True –ve (40)	60
Total	61	41	102

In our study, in the diagnosis of appendicitis with the combination of Alvarado and ultrasound (both positive), true +ve cases are 41 and false –v e cases are 20 and in non-appendicitis, false +ve cases are 1 and true –Ve cases are 40.

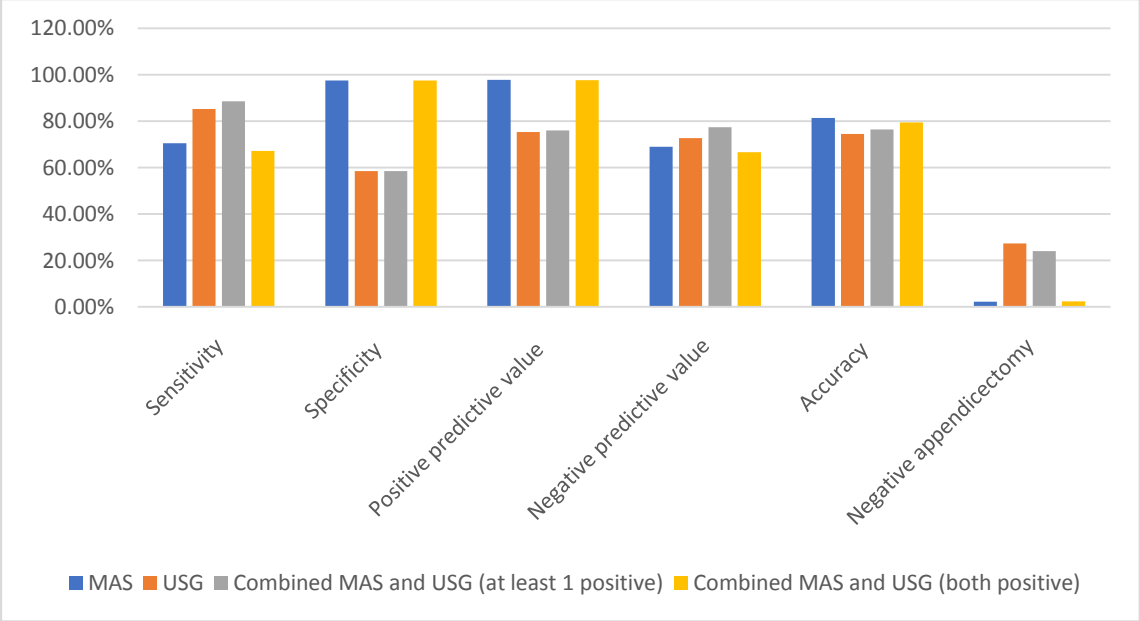
In our study with the combination of Alvarado and ultrasound (both positive), Sensitivity =67.21 %, Specificity=97.56%, Positive predictive=97.62%, Negative predictive=66.67%, Accuracy=79.4%, Negative appendicectomy rate (false positive) =2.38%.

Modified Alvarado score, Ultrasound and combined MAS and Ultrasound compared with Histopathology

		Appendicitis	No appendicitis	Total	
MAS	≥7	43	1	44	102
	<7	18	40	58	
USG	+ve	52	17	69	102
	-ve	9	24	33	
Combined MAS and USG (at least 1 positive)	+ve	54	17	71	102
	-ve	7	24	31	
Combined MAS and USG (both positive)	+ve	41	1	42	102
	-ve	20	40	60	

Comparison between Modified Alvarado score and Ultrasonography and their combination in diagnosing acute appendicitis

	MAS	USG	Combined MAS and USG (at least 1 positive)	Combined MAS and USG (both positive)
Sensitivity	70.49%	85.25%	88.52%	67.21%
Specificity	97.56%	58.54%	58.54%	97.56%
Positive predictive value	97.73%	75.36%	76.06%	97.62%
Negative predictive value	68.97%	72.73%	77.42%	66.67%
Accuracy	81.37%	74.51%	76.47%	79.4%
Negative appendicectomy	2.27%	27.27%	23.94%	2.38%



Combination of Alvarado score and Ultrasonography with at least one positive has proven to be effective in the diagnosis of acute appendicitis as it has a higher sensitivity and higher negative predictive value. When USG and Alvarado score are combined with both positive, the specificity is increased and negative appendicectomy rate is reduced. When Alvarado score alone is considered, diagnostic accuracy is high and negative appendicectomy rates are least.

V. Discussion

This study involved 102 patients suspected to have appendicitis admitted to Gauhati medical college and hospital, Guwahati for a period of 12 months. At the end of the study, it was found that age group of patients in which Maximum number of cases presented was from 21- 30 years of age. Male patients outnumbered female patients.

In our study patients with age >12 years (The overall mean age being 26 years). The highest occurrence was seen in 52 of the patients (50.9%) was seen in age group of 21-30 years.

In our study the total number of male patients are 54 (53%) and number of female patients are 48 (47%) and M: F Ratio is 1.125:1 in our study sex distribution with modified Alvarado scoring.

In our study, out of the 44 patients with score≥7, 43 patients had Histopathology report positive acute appendicitis while 1 patient had histopathology reporting normal appendix. Patients with positive histopathology, 23 of them (53.5%) were female, while 20 patients (46.5%) were males. Patient having negative histopathology (1) is a male patient. Negative appendicectomy rate of patient with modified Alvarado score >7 was 2.27%.

In our study, Patients with positive histopathology, 31 of them (50.82%) were females, while 30 patients (49.18%) were males. Patients having negative histopathology, 18 of them (43.9%) were females while 23 patients (56.1%) were males, Negative appendectomy rate for patients with Modified Alvarado Score > 7 were 2.27%. Out of the 58 patients with modified Alvarado score <7, 18 patients had Histopathological positive acute appendicitis while 40 patients had Histopathological normal appendix

So overall negative appendicectomy rate in our study regardless of modified Alvarado scoring is 71.3%

Out of the 44 patients with score≥7, 43 patients had Histopathology report positive acute appendicitis while 1 patient had histopathology reporting normal appendix. Patients with positive histopathology, 23 of them (53.5%) were female, while 20 patients (46.5%) were males. Patient having negative histopathology (1) is a male patient.

Diagnostic accuracy and negative appendicectomy rate in male and Female

	Jess et al [7]	Hemant Nautiyal and et al [8]	Our study
Diagnostic accuracy	70-75	92%	72.55%
(Male)Negative appendectomy rate	25%	7.14%	38.4%
(Female)Negative appendectomy rate	35-45%	11.11%	12.5%

Diagnostic accuracy in our study is comparable with Jess et al. While negative appendectomy rate in males is more in our study as compared to Jess et al and in females, it is in-between

Diagnostic approach and ultrasonography

	Hemant Nautiyal et al.-diagnostic [8]	Hemant Nautiyal et al.-ultrasonography [8]	Our study-diagnostic	Our study - ultrasonography
sensitivity	97.14%	88.57%	85.25%	85.25%
specificity	80.5%	86.67%	53.66%	58.54%
Positive predictive value	91.89%	93.94%	73.24%	75.36%
Negative predictive value	92.32%	76.47%	70.97%	72.73%
Accuracy	92%	88%	72.55%	74.51%
Negative appendectomy rate		6.06%	26.27%	27.27%

Our diagnostic approach with our ultrasonography results are almost comparable and sensitivity of ultrasonography which is less as compared to, Hemant Nautiyal et al. Negative appendectomy rate is more in our study.

Comparison between Modified Alvarado scoring and Ultrasonography in diagnosing acute appendicitis

	MAS in Dhiraj T and et al [9]	MAS in our study	USG in Dhiraj T and et al [9]	USG in our study
Sensitivity	82.42%	70.49%	92.31%	85.25%
Specificity	100%	97.56%	100%	58.54%
Positive predictive value	100%	97.73%	100%	75.36%
Negative predictive value	36%	68.97%	56.25%	72.73%

The specificity and positive predictive value of Alvarado score in our study is comparable with those of Dhiraj T and et al. study. But all of the parameters for ultrasonography are high in case of Dhiraj T and et al study in comparison to our study.

Sensitivity and specificity in combination of Alvarado and ultrasound

	Combined MAS and USG (at least 1 positive)- Shivakumar S and et al.[10]	Combined MAS and USG (both positive)- Shivakumar S and et al.[10]	Combined MAS and USG (at least 1 positive)- our study	Combined MAS and USG (both positive)- our study
Sensitivity	88.71%	25.81%	88.52%	67.21%
Specificity	44.74%	97.37%	58.54%	97.56%
Positive predictive value	72.37%	94.12%	76.06%	97.62%
Negative predictive value	70.83%	44.58%	77.42%	66.67%
Accuracy	72%	53%	76.47%	79.4%
Negative appendicectomy	27.63%	5.8%	23.94%	2.38%

In combination of USG and Alvarado scoring, when at least of the factor considered to be positive, the results of our study are comparable to those of Shivakumar S et al. When both the factors considered to be positive, the results of our study is better in comparison with Shivakumar S and et al.

Both our study and the study of Shivakumar S and et al showed that combination of Alvarado score and Ultrasonography (at least one positive) has proven to be effective in the diagnosis of acute appendicitis as it has a higher sensitivity, higher negative predictive value. When both USG and Alvarado score are positive, the specificity is increased.

VI. Conclusion

Following conclusions can be drawn from our prospective study,

1. When Alvarado score alone is considered, diagnostic accuracy is highest and negative appendicectomy rates are least.
2. The combination of Alvarado score and Ultrasonography with at least one positive has proven to be effective in the diagnosis of acute appendicitis as it has a higher sensitivity, higher negative predictive value.
3. When USG and Alvarado score are combined with both positive, the specificity is increased and negative appendicectomy rate is reduced.

Thus, finally it may be concluded that a combination of Alvarado score and Ultrasonography is a better diagnostic tool in diagnosing acute appendicitis when compared to either Alvarado score or Ultrasonography separately. The combination can decrease the need for unnecessary radiological investigations and also decrease the rate of negative appendicectomies.

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