Combined Use of Modified Alvarado Score and Focused Appendicitis Ultrasonography in Predicting Acute Appendicitis in Children: How to Reduce the Need for Unnecessary Ct Scans

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Abstract

Introduction: Acute appendicitis is one of the most common abdominal emergencies worldwide. The Modified Alvarado score is 9-point scoring system for diagnosis of appendicitis based on clinical signs and symptoms and differential leucocyte count. Previous studies have suggested that Alvarado score alone is inadequate as a diagnostic test**,** but it has been advocated as a means of selecting patients who should undergo imaging.

To evaluate the effectiveness of Modified Alvarado Score and Focused Appendicitis Ultrasonography in predicting acute appendicitis and to compare the accuracy of two modalities alone and combined.

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Materials and Methods:
The study was performed in the postgraduate department of General Surgery, Government Medical College, Jammu over a period of one year from November 2021 to October 2022. 100 patients who were under the age of 18 years irrespective of their gender suspected to have appendicitis were included in the study.

Results: There were 64 males and 36 females. The majority of patients were in the age group of 12-15 years (51%). Modified Alvarado Score alone has sensitivity of 84.51%, specificity of 33.33%, Positive predictive value of 83.53%, negative predictive value of 34.98% and accuracy of 74.27%. Focused ultrasonography alone has sensitivity of 100% and accuracy of 80.00%, positive predictive value of 80%. The combined sensitivity of MAS+ focused appendicitis ultrasonography is 98.80 % with specificity of 11.76%, positive predictive value of 81.75%, negative predictive value of 70.94% and accuracy of 81.39%. The percentage of negative appendectomies was 14.45%.

Conclusion: The sensitivity of Modified Alvarado Score is less than the sensitivity of Focused Appendicitis Ultrasonography. When both investigations combined together, their sensitivity, specificity, positive value, negative predictive value and the accuracy improves the diagnosis of acute appendicitis.

Keywords

- Acute Appendicitis
- Modified Alvarado Score
- Focussed Ultrasonography
- Leucocytosis

Introduction

Acute appendicitis is one of the most common abdominal emergencies worldwide. With a lifetime frequency of one in seven, acute appendicitis is the most common surgical emergency.[1] The cause remains poorly understood with few advances in the past few decades to obtain a confident preoperative diagnosis is still a challenge as the possibility of appendicitis must be entertained in any patient

presenting with an acute abdomen. Although biomarkers and imaging are valuable adjuncts to history and examination, their limitations mean that clinical assessment is still the mainstay of diagnosis. A clinical classification is used to stratify management based on simple (non-perforated) and complex (gangrenous or perforated) inflammation, although many patients remain with an equivocal diagnosis which is one of the most challenging dilemmas. An observed divide in disease course suggests that some cases of simple appendicitis might be self-limiting or respond to antibiotics alone whereas another type often seems to perforate before the patient reaches hospital. Although the mortality rate is low, postoperative complications are common in complex disease. It is important to discuss existing knowledge in pathogenesis, modern diagnosis and evolving strategies in management that are leading to stratified care for patients with acute appendicitis.[2] The Modified Alvarado score is a 9-point scoring system for the diagnosis of appendicitis based on clinical signs and symptoms and differential leucocyte count. Scoring system recommended surgical intervention for all patients with a score of 7 or more and observation for patients with scores of 5 or 6.[3] Subsequent prospective studies have suggested that the Alvarado score alone is inadequate as a diagnostic test**,** but it has been advocated as a means of selecting patients who should undergo imaging.[4]

Aims and objectives:

- To evaluate the correlation of Modified Alvarado Score and Focused Appendicitis Ultrasonography in predicting acute appendicitis in children for timely diagnosis of acute appendicitis to prevent further complications.
- To determine the sensitivity, specificity and predictive value of Modified Alvarado Score in suspected acute appendicitis in children.
- To determine the sensitivity, specificity and predictive value of Focused Appendicitis Ultrasonography in the diagnosis of acute appendicitis in children.
- To determine the sensitivity, specificity and combined accuracy of Modified Alvarado score and focused appendicitis

ultrasonography for the diagnosis of acute appendicitis in children.

Materials and Methods

The present study was performed in the Postgraduate Department of General Surgery, Government Medical College, Jammu over a period of one year from November 2021 to October 2022. 100 patients were included in this study and all the patients under the age of 18 years irrespective of their gender who presented with history of right lower quadrant pain were evaluated by history, clinical examination and routine blood investigations especially complete blood counts to obtain the Modified Alvarado Score. Alvarado Score consists of three symptoms, three signs and a laboratory finding as described by Alvarado and later modified by Kalan *et al.*[5]

Modified Alvarado score

Symptoms/Sign/Investigation	Score
Symptoms	
Migration of pain to right iliac fossa	1
Anorexia	1
Nausea/Vomiting	1
Signs	
Tenderness over right iliac fossa	2
Rebound tenderness over right iliac fossa	1
Temperature > 37.5ºC (99.5 F)	1
Investigation	
Leukocytosis> $10x10^9$/L	2
Total	9

Depending upon the Modified Alvarado Score, the patients were divided in to three categories:

Category-1 (MAS = 1-4) -Appendicitis unlikely

Category-2 (MAS = 5-6) -Appendicitis possible/ equivocal results

Category-3 (MAS = 7-9) -Appendicitis probable/definitive.[6]

All patients then underwent focused appendicitis ultrasonography to confirm the diagnosis and to know the false positive and false negative results of Modified Alvarado Score alone. On the basis of Focused Appendicitis Ultrasonography, the patients were further divided into 3 groups:

Group1: Negative focused appendicitis ultrasonography- Visualized compressible appendix and less than
6 mm in diameter.

Group2: Positive focused appendicitis ultrasonography – non compressible appendix and more than 6 mm in diameter, adherent omentum and hyperemia will be also considered positive findings.

Group3: Equivocal focused appendicitis ultrasonography – if appendix non-visualized. These patients were then subjected to further radiological investigations like CT scan to know the other causes of pain abdomen, abdominal/pelvic pathology to reduce the chances of negative appendectomies and further complications. All the specimens of appendix were sent for histopathological confirmation of acute appendicits. Then the results of MAS and focused appendicitis ultrasonography were compared with intraoperative/ histopathological examination to know the sensitivity, specificity, negative and positive predictive value and accuracy of MAS and focused appendicitis ultrasonography.

STUDY DESIGN: A Prospective study

INCLUSION CRITERIA

1. All children below 18 years of age (irrespective of gender), presenting in emergency and surgery wards with suspected acute appendicitis.
2. All patients who were willing to participate in the study.

EXCLUSION CRITERIA

1. Children above 18 years of age
2. Children with appendicular lump

The study was conducted on all the patients (children) below 18 years of age presenting to Government Medical College surgery

emergency. Patients presenting with pain in the right lower quadrant of abdomen after clinical examination, provisionally diagnosed to have Acute Appendicitis were admitted. Patients were chosen according to inclusion and exclusion criteria and selected for the study. A pretested proforma was used to collect relevant information (patient data, clinical findings, lab investigations, ultrasonography findings, etc.) from all the selected patients. Preoperatively, modified Alvarado score and focused appendicitis ultrasonography were assigned to those included in the study. Intra-operative findings and histopathological reports were followed up and the results were compared with modified Alvarado score and focused appendicitis ultrasonography to determine the sensitivity, specificity, positive and negative predictive values and the accuracy of Modified Alvarado Score and Focused Appendicitis ultrasonography in the diagnosis of acute appendicitis in children using appropriate statistical analysis.

Result

A total of 100 patients were included in the study. The majority of patients in our study were in the age group of 12-15 years. 51 patients (51%) followed by 31 patients (31%) in the age group of 16-18 years, 13 patients (13%) in the age group of 8-11 years and 5 patients (5%) in the age group of 4-7 years and there were no patients in the age group of 0-3 years. The mean age is 14.5 years. **(Table 1)** There were 64 males and 36 females in our study. There were 30 males and 21 females in the age group of 12-15 years, 23 males and 8 females in the age group of 16-18 years, 7 males and 6 females in the age group of 8 -11 years and 4 males and 1 female in age group of 4– 7 years with a male to female ratio of 1.7:1. **(Table 1)**

Table 1: Distribution of patients as per Age and Gender

AGE (IN YEARS)	MALE	FEMALE	TOTAL	PERCENTAGE
4-7	4	1	5	5%
8-11	7	6	13	13%
12-15	30	21	51	51%
16-18	23	8	31	31%
TOTAL	64	36	100	100%

In our study, 99 patients (99%) presented with migration of pain in the right iliac fossa. Seventy-five patients (75%) presented with complaints of nausea and vomiting. Seventy-five patients (75%) presented with complaints of anorexia. Tenderness in right iliac fossa was felt in all the patients while sixty-eight patients (68%) had rebound tenderness. Fourty eight patients (48%) presented with elevated temperature(fever). Seventy-four patients (74%) show leucocytosis in their blood films. **(Table 2)** As per Modified Alvarado Score out of 100 patients, 3(3%) patients fall in category 1 of MAS 1-4, 24 (24%) patients fall in category 2 of MAS 5-6 and 73 (73%) patients in category 3 of MAS 7-9. In our study, on the basis of focused appendicitis ultrasonography 2% patients in group1, 83%patients in group2 and 15% patients were in group3.

Table 2: Distribution of the patients according to the modified alvarado score components.

Component	FREQUENCY	PERCENTAGE
MIGRATION OF PAIN	99	99
Nausea/vomiting	75	75
Anorexia	75	75
Tenderness	100	100
Rebound Tenderness	68	68
Elevated Temperature	48	48
Leucocytosis	74	74

In our study, out of 100 patients, 15patients were operated who had Modified Alvarado Score between 1-6, 11patients were having appendicitis on intra operative findings and on histopathological examination and 4 were negative appendectomies and 68patients who had Modified Alvarado Score between 7-9, 60patients were having appendicitis on intra operative findings and on histopathological examination and 8 were negative appendectomies with a sensitivity of 84.51%, specificity of 33.33%, Positive predictive value of 83.53%, negative predictive value of 34.98% and accuracy of 74.27%. **(Table 3)**

Table 3: Result of operated patients on the basis of mas compared with intraoperative iof/ hpe

Modified alvarado score	Diagnosis on hpe		Total
	appendicitis	Normal appendicitis	
1-6	11	4	15
7-9	60	8	68
TOTAL	71	12	83

SENSTIVITY= 84.51%, SPECIFICITY= 33.33%, PPV= 83.53%
NPV= 34.98%, Accuracy = 74.27%.

In our study out of 100 patients, 83 patients were operated on the basis of positive focused appendicitis ultrasonography and out of which 12 patients were having normal appendix intraoperatively and on histopathological examination and marked as negative appendicectomies and remaining 71 were having inflamed appendix intraoperatively and on histopathological examination, showing sensitivity of 100% and accuracy of 80.00%, positive predictive value of 80%. **(Table 4)**

Table 4: Focused appendicitis ultrasonography findings compared with inttraoperative findings / histopathological examination

Ultrasound	Diagnosis on hpe		Total
	Appendicitis	Normal appendicitis	
Positive	71	12	83
Negative	0	0	0
Total	71	12	83

SENSTIVITY= 100%, SPECIFICITY= 00%, PPV= 80%
NPV= nil, Accuracy = 80.00%

In our study out of 100 patients, on the basis of positive findings of Modified Alvarado Score and focused appendicitis ultrasonographic results, 83 patients were operated and 71 patients were having inflamed appendix intraoperatively and on histopathological examination, 12 patients were having normal appendix both intraoperatively and on histopathological examination In our study the combined sensitivity of MAS + focused appendicitis ultrasonography is 98.80 % with a specificity of 11.76%, positive predictive value of 81.75%, negative predictive value of 70.94% and with accuracy of 81.39%. **(Table 5)**

Among the 17 patients left (non appendicitis patients), 2 patients had urinary tract infections and 15 patients who had equivocal results were taken for CT scan showing other differentials like ovarian cysts 3 patients, mesenteric lymphadenitis 8 patients, intestinal colic 2 patients, urinary tract infection 2 patients, pelvic inflammatory disease 2 patient.

Table 5: Result of operated patients on the basis of mas and focused appendicitis ultrasonography findings combined together and compared with intraoperative findings/ histopathological examination.

Mas + ultrasound	Diagnosis		Total
	Appendicitis	Normal appendicitis	
Mas > 6 + mas 5-6 with positive usg	82	15	97
Mas <5 + mas 5-6 with negative usg	1	2	3
Total	83	17	100

SENSTIVITY= 98.80%, SPECIFICITY= 11.76%, PPV= 81.75%, NPV= 70.94%, Accuracy = 81.39%

Discussion

In our study the age of the patients was in the range of 4-18 years. Majority of the patients were between 12-15 years. There were 51 patients (51%) in this age group. A study done by Hussain M et al in which the commonest age group was 5-10 years, they had 60 patients in their study in which they had 35 patients in the range of 5-10 years and the age range in their study was 0-18 years.[7] In our study out of the 100 patients there were 64 were males and 36 were females with male: female ratio of 1.7:1. A study done by Hussain M et al in which they had 38 males and 22 females in a total of 60 pediatric age group patients.[7] Another study by Khan I et al in their study on 100 patients, 59 were females and 41 were males.[8] In another study Netta M et al studied a total of 522 patients in which they had 231 males and 291 females in their study.[9] In our study the commonest presentation was tenderness (100%) followed by migratory pain (99%), nausea and vomiting (75%), anorexia (75%), leukocytosis (74%), rebound tenderness (68%) and elevated temperature in 48% patients. Similar results were found by Hussain M et al and Peyvastah M et al.[7-10] In the study by Fashina IB et al, pain right iliac region is commonest presentation seen in all the patients.[11] In the present study the sensitivity of the Modified Alvarado score is 84.51%, specificity of 33.33%, positive predictive value of 83.53%, negative predictive value of 34.98% and with accuracy of 74.27%. In the study by Dsouza C et al, sensitivity of MAS was 97.56%, specificity was 66.67% and accuracy was 87.2%.[12] In another study by Kunumba ES et al, sensitivity of MAS was 94%, specificity was 90.4% and accuracy was 92.9%.[13] The sensitivity of focused appendicitis ultrasonography in diagnosing patients as appendicitis in our study is 100% with positive predictive value of 80%, and with accuracy of 80.00%. in the study by Kaiser S et al, focused ultrasonography has sensitivity of 86% with positive predictive value of 91% and diagnostic accuracy of 93%.[14] in another study by Stephens PL et al, ultrasound alone resulted in correct diagnosis in 87% of patients with 10% false negatives and 4.6% false positives. The combined sensitivity of Modified Alvarado score and Focused appendicitis ultrasonography is 98.80%, with combined specificity of 11.76%, with a positive predictive value of 81.75%, with a negative predictive value of 70.94% and the combined accuracy of 81.39%. Our

findings are consistent with the present literature. In our study the percentage of negative appendectomies is 14.45% (12/83). In the study by Stephens PL et al, rate of negative appendectomies was 10.6%.[1] In the study by Kaiser S et al, overall rate of negative appendectomies was 3.7%.[14]

Conclusion

The conclusion from our study is that the sensitivity of Modified Alvarado Score is less than the sensitivity of Focused Appendicitis Ultrasonography. When both these investigations combined together, their sensitivity, specificity, positive value, negative predictive value and the accuracy improves in the diagnosis of acute appendicitis. Also, with these two combined modalities the false positive cases can be reduced. The need to go for unnecessary CT scans can also be reduced.

Ethical Consideration

The study is approved by the ethical committee, GMC Jammu with code number IEC/GMC/2022/1223.

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Not applicable

Conflict of interests

There is no conflict of interest

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