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PASTER Score: Decision Making in Acute Appendicitis Made Easy

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Abstract
Introduction: *Acute appendicitis is the most frequent surgical emergency encountered worldwide and diagnosing it may be difficult at times and therefore many scoring systems have been devised. However, most of them include many clinical and laboratory variables, making them impractical to be applied at field areas. We devised a pure bedside novel scoring system: PASTER score, to overcome these limitations.*
Objective: *To frame a completely clinical scoring system independent of any lab values/imaging modality, which could aid in the diagnosis of acute appendicitis amongst the military population and compare it with time tested Alvarado scoring system. This study was to compare the efficacy of PASTER score with Alvarado score in the diagnosis of acute appendicitis.*
Materials and Methods: *An observational prospective study was conducted between Jan 2014 to Aug 2016 on 155 patients who were diagnosed as Acute Appendicitis and had undergone emergency appendicectomy based on clinical judgement. PASTER and Alvarado score were calculated in all these patients at the time of admission. The histopathology diagnosis was used as the gold standard against which diagnostic performance of Alvarado score and PASTER score were compared.*
Results: *The complete data of 155 serving soldiers was analyzed at the end of the study period. The mean age was 27.73 ± 9.46 years. A negative appendectomy rate of 7.1% was observed during the study. The diagnostic performance of PASTER score was superior to that of Alvarado score with sensitivity, specificity and diagnostic accuracy of 95.14% versus 86.11%, 63.64 versus 27.27%, and 93% versus 82%respectively (p-value < 0.001).*
Conclusion: *PASTER score is a very simple, fast and an effective modality to establish the diagnosis of acute appendicitis with a very high accuracy thus reducing delay in diagnosis and unnecessary referrals to higher centers and therefore, it is very relevant in armed forces setup. Its relevance in general public remains to be studied.*
Keywords: *Appendicitis, Alvarado score, PASTER score, Appendicectomy.*

Introduction

Acute appendicitis (AA) is one of the most common surgical emergency with a life time risk of 7%.[1] Although history and clinical examination still remain the mainstay for the diagnosis for AA, its accuracy is only 70-87% with high negative appendicectomy rate.[2][3] High Negative appendicectomy rate was previously considered acceptable at the cost of preventing appendicular perforation.[1][4] However, recent studies have shown that negative appendicectomy and perforation of appendix are independent risk factors and are not inversely related.[5] Moreover, negative appendicectomy can be associated with morbidity of 12%.[6]

Timely and Accurate diagnosis reduces mortality and morbidity. In the armed forces set-up where in the majority of population is living and working in far flung and remotely accessible areas, which are usually devoid of diagnostic and imaging modalities. Such a situation is seen in remote civil areas too where people do not receive adequate medical facilities and the physicians there are resource constrained. It becomes very important for the medical officer at the periphery to diagnose appendicitis and refer the patient in time, so as to ensure that the patient reaches the higher center well in time. Keeping this point in mind, we decided to frame a completely clinical scoring system independent of any lab values/imaging modality, which could aid in the diagnosis of acute appendicitis and compare it with time tested Alvarado scoring system.[7]

A vast number of clinical scoring systems are in use for easing out the ordeal of clinical diagnosis of acute appendicitis.[3,7,8,9,13,14] The most popular and widely accepted score is the Alvarado score, which was created in 1986 by A Alvarado. This Alvarado scoring system is based on three symptoms, three signs, and two laboratory findings with a total of 10 points (Table 1). A total score of 7 or more is considered to be diagnostic of appendicitis and the patient requiring surgery.[10]

We found Alvarado score not without limitations. It is (i) cumbersome to remember (ii) dependent on laboratory facilities (iii) time consuming [approx. 2hrs, depending on availability of pathologist to report on Peripheral blood smear for shift to left]. (iv) further imaging is required for equivocal cases (v) low diagnostic accuracy in children, ladies, Asian population.[9][12] &(vi) important clinical parameters are not given proportionate weightage, instead there is significant weightage on the laboratory values amounting to 30% of the score.

We noticed that in literature most of the scoring systems when devised, based their accuracy on the final histopathological finding of appendicectomy specimen. These operated patients were diagnosed as AA based on the clinical judgement of the surgeon.[3,7,8,9,13,14] This emphasised the concept that diagnosis of AA relies largely on clinical experience. Hence, we decided to devise a scoring system which would objectify this clinical experience into an understandable and communicable score. Therefore, we questioned and discussed with other general and gastrointestinal surgeons, who were routinely involved in diagnosing and operating upon appendicitis patients, across various professional platforms about their experience in diagnosing AA. Finally, in order to device a very simple score we zeroed down on six of the most significant clinical parameters in diagnosing AA and included them into the making of a novel score- PASTER SCORING SYSTEM (Table 1).

PASTER score is based completely on clinical evaluation, making it a totally bedside score which is quick and independent of lab/imaging modalities, thus much suitable as a referral tool in the hands of our field medical officers or general physicians. There are altogether six variables, three of which are symptoms based on history provided by the patient and three clinical signs, easily elicitable at the bedside. The three symptoms variables are pain in right iliac fossa (RIF), anorexia & shifting pain from periumbilical region to RIF, being assigned 2,1,2 points,

respectively and three signs variables are tenderness at McBurney's point, elevated temperature above 100°F & rebound tenderness in RIF, being assigned 2,1,2 points, respectively. The mnemonic for the score is PASTER and hence the name of the scoring system. The total points of the score are 10. A score of 6 or more was considered positive for AA. Whereas a score of 5 or less was considered negative for AA.

Methods

A prospective, observational study was carried out at COMMAND HOSPITAL AIR FORCE, BANGALORE. Between January 2014 and August 2016, a total of 164 patients with the clinical diagnosis of AA were assessed for eligibility; of these eight patients with peritonitis, appendicular abscess, appendicular lump were excluded from the study, three others refused to participate. Finally a total of 155 patients who underwent emergency appendectomy were selected for this study. Informed consent was obtained from all patients. Being a study focused upon serving soldiers aged 19 to 58 years [mean age -27.73], all other patients [Geriatric patients, women and children] were not included in this study.

Clinical diagnosis of AA was made by experienced surgeons purely on their clinical judgement and were not part of the study, and then ALVARADO AND PASTER scores were calculated in all patients by the same Surgery Resident. These serving soldiers with the clinical diagnosis of AA underwent abdominal ultrasonography (USG), total & differential leukocyte counts and peripheral blood smear by pathologist as a part of their assessment before undergoing emergency appendicectomy.

At the time of admission, Alvarado and PASTER score were calculated for patients suspected to have AA. Appendicectomy was done, if considered necessary based on the clinical judgement of operating surgeon, irrespective of PASTER or Alvarado score. Histopathological diagnosis of AA was considered final for AA.

Statistical Analysis

Descriptive analysis was done using, mean and standard deviation for quantitative variables, frequency and percentages for categorical variables. The association between the screening test findings and the gold standard test was done by cross tabulation and chi square test. The validity of the two screening test in diagnosing appendicitis was assessed by calculating sensitivity, specificity. Positive and negative predictive values and overall diagnostic accuracy of both the tests were calculated. Reliability of both the tests was assessed by kappa statistic. 95% CI of all the parameters were presented. *P* value < 0.05 was considered as statistically significant. IBM SPSS version 21 was used for statistical analysis.

Results

A total of 155 participants were included in the analysis. The mean age was 27.73 years in study population and the mean duration of presentation from the onset of RIF pain was 20.5 hours. The most common position of the appendix was retroceacal (81%). 144 patients (92.9%) had histologically proven AA.

The number of participants who reported as AA on USG was 139 (89.7%) and normal study was observed in 16 (10.3%) cases (Table 2). The proportion of participants with PASTER score positive and negative for AA were 91% and 9% respectively in study population. (Table 3). The proportion of participants with HPE report as positive and negative for AA were92.9% and 7.1% respectively in this study population. (Table 2).

Out of 144 HPE positive participants, (n=124) (93.9%) of the cases could be diagnosed by positive Alvarado score and out of 11 HPE negative participants only (n=3) (13%) could be ruled out by negative Alvarado score. The association between the Alvarado score and HPE were statistically not significant. (The chi-square value 1.449, P-value 0.23). Out of 144 HPE positive participants, (n=137) (97.2%) of the cases

could be diagnosed by positive PASTER score and (n=7) (50%) of the cases were ruled out by negative PASTER score. The association between the PASTER score and HPE were statistically significant (The chi-square value 42.966 P-value <0.001) (Table 3).

When compared to HPE, Alvarado score had a sensitivity of 86.11% (95% CI was 80.46% to 91.75, specificity was 27.27% (95% CI was 0.954% to 53.59%), False positive rate was 72.73% (95% CI was 46.40% to 99.04%) and False negative rate was 13.89% (95% CI was 8.24% to 19.53%). The Positive predictive value & Negative predictive value were 93.94% (95%CI 89.86% to 98%) and 13.04% (95% CI -0.72% to 26.80%).The Diagnostic accuracy was 82% (95%CI 75.87% to 87.99%) (Table 4).

When compared to HPE, PASTER score had a sensitivity of 95.14% (95% CI was 91.62% to 98.65%, specificity was 63.64% (95% CI was 35.20% to 92.06%), False positive rate was 36.36% (95% CI was 7.93% to 64.79%) and False negative rate was 4.86% (95% CI was 1.34% to 8.373%). The Positive predictive value & Negative predictive value were 97.16% (95%CI 94.42% to 99.90%) and 50.00% (95% CI 23.80% to 76.19%). The Diagnostic accuracy was 93% (95%CI 88.86% to 96.94%) (Table 4).

The PASTER Score was compared to the Alvarado-score using Receiver Operating Characteristic (ROC) analysis and area under ROC curve (AUC). In this comparison, the PASTER Score had significantly better value of AUC than Alvarado Score, indicating improved ability of the PASTER score to correctly diagnose AA (Figure 1)

Table 1: Alvarado and PASTER scoring system for acute appendicitis

	Alvarado Score		***PASTER*** Score	
Symptoms	Migratiory RIF Pain	1	***P***ain	2
	Nausea/Vomiting	1	***A***norexia	1
	Anorexia	1	***S***hifting *(Pain)*	2
Signs	RIF tenderness	2	***T***enderness	2
	Elevation of temperature	1	***E***levated Temperature	1
	Rebound tenderness RIF	1	***R***ebound *(Tenderness)*	2
Laboratory findings	Leucocytosis	2	**NOT CONSIDERED**	
	Shift to the left	1		
TOTAL		**10**		**10**

Table 2: Descriptive analysis of Alvarado Score, PASTER Score, ultra sound abdomen & HPE finding in study group (N=155)

Result	**Alvarado Score Frequency(percentage)**	***PASTER* Score Frequency (percentage)**	**USG Correlation Frequency (percentage)**	**HPE Finding Frequency (percentage)**
Positive	132 (85.16%)	141 (91.0%)	139 (89.7%)	144 (92.9%)
Negative	23 (14.84%)	14 (9.0%)	16 (10.3%)	11 (7.1%)

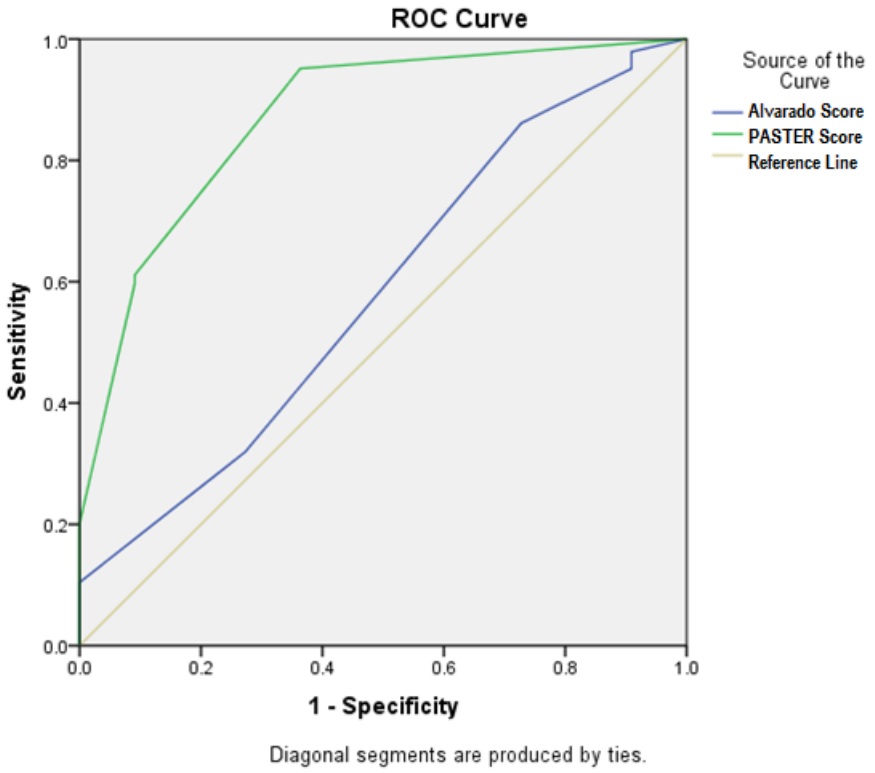
Table 3: Association between HPE and Alvarado & PASTER Score across the study groups (N=155)

Parameter	**HPE**		**Chi square**	**P value**
	Positive	**Negative**		
Alvarado Score				
Positive	124 (93.9%)	8 (6.1%)	1.449	0.23
Negative	20 (87%)	3 (13%)		
PASTER Score				
Positive	137(97.2%)	4 (2.8%)	42.966	<0.001
Negative	7 (50%)	7 (50%)		

Table 4: Validity of Alvarado & PASTER scores with HPE in study group (N=155)

Parameter	ALVARADO SCORE			PASTER SCORE		
	Value	95% CI		Value	95% CI	
		Lower	Upper		Lower	Upper
Sensitivity	86.11%	80.46%	91.75%	95.14%	91.62%	98.65%
Specificity	27.27%	0.954%	53.59%	63.64%	35.20%	92.06%
False positive rate	72.73%	46.40%	99.04%	36.36%	7.936%	64.79%
False negative rate	13.89%	8.240%	19.53%	4.86%	1.348%	8.373%
Positive predictive value	93.94%	89.86%	98.00%	97.16%	94.42%	99.90%
Negative predictive value	13.04%	-0.72%	26.80%	50.00%	23.80%	76.19%
Diagnostic accuracy	82%	75.87%	87.99%	93%	88.86%	96.94%

Figure 1ROC-Curve presenting the comparison of PASTER Score [AUC 0.581(95% CI 0.403-0.758) *p* Value 0.372] compared with Alvarado Score [AUC 0.870 (95% CI 0.758-0.982) *p* Value <0.001]



Discussion

The diagnosis of acute appendicitis at times can perplex even an experienced surgeon. Life threatening complications can arise if patient is not operated in time due to incorrect or delay in diagnosis of AA by the referring medical officers posted to remote areas which usually lack laboratory and radiological facility. These medical officers have to rely entirely on their clinical judgement, hence, evidence based, purely clinical, bedside score for the diagnosis of AA is a much-felt need by them.

Andersson RE[15] conducted a meta-analysis (with a total of 24 studies) on 28 predictors out of which 22 were clinical and he found that amongst the clinical variables a history of migratory pain and descriptors of peritoneal irritation like rebound tenderness yield the most diagnostic information on AA. Rightly so, maximum marks were accorded to these sign and symptom in our *PASTER* score, and this also corroborates with other studies.[16][17][18]

Though the sensitivity of Alvarado score in the current study (86.11%) was comparable with literature.[7][19] But, the specificity of in our study

(27.77%) was low. However, the sensitivity, specificity and accuracy of PASTER score was 95.14 %, 63.64% and 93% respectively.

The PASTER score correctly diagnosed AA in 95.14% of patients using the cut off score ≥ 6, compared to only 86.11% when using Alvarado score. There was a statistically significant ($p<0.001$) difference in diagnostic accuracy between PASTER score and Alvarado score. Same conclusion was drawn in a study conducted by Man E et al[20] where they found that clinical judgement is more reliable in the diagnosis of acute appendicitis than Alvarado score, and this can be explained by the fact that almost one third of the Alvarado score is based on laboratory findings, which is unreliable and inferior to clinical judgement.[21][22]

The negative appendicectomy rate of 7% was low compared to literature, as majority of our patients were referred from peripheral medical units and therefore presented late (mean duration >24 hours). As time passes the inflammatory response also flares up, which in turn increases the rate of positive clinical findings as well as laboratory parameters for AA.[15] This, probably would have contributed to a more accurate preoperative diagnosis and hence the relatively lower rate of negative appendectomy in our setup.

The limitations of this study are that it is an underpowered study. However, it does show promising result with the pure clinical score - PASTER. We presume that this scoring system will not only benefit the referring medical officer but also help the surgeon in decision making for appendicectomy. Further, well designed studies with adequate sample size would be required to validate the results of this study.

Conclusions

We conclude by reinstating that, the tripod of diagnosing appendicitis rests on good clinical judgment, investigations and clinical scoring system, all of these combined, help to reduce the negative appendectomy rate. Our study revealed that PASTER scoring system is a standalone clinical score, that can be used bedside as a very effective modality to establish the diagnosis of AA. We propose to make the field medical officers aware of this novel, purely clinical scoring system and take inputs from their experiences to generate a healthy criticism to further refine this score. It also will help in a higher accuracy thus leading to a very low negative appendectomy rate. However, its role and applicability to the general population needs to be supplemented by larger studies.

Conflicts of Interest: No conflicts of interest to disclose. We have no grant or financial support.

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